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Engineering Design File

PROJECT NO. 23833

OU 7-13/14 In Situ Grouting Project Measurement and Controls

Idaho National Engineering and Environmental Laboratory

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5. Summary:

The purpose of this engineering design file (EDF) is to discuss and conceptually identify instrumentation, data measurement and control systems, and components that could satisfy the contractor requirements for a successful In Situ Grouting (ISG) Project. Specifically, this would include the grout ingredient storage subsystem, grout low-pressure subsystem, grout high-pressure subsystem, and the grout injection-positioning subsystem. Any or all of these subsystems, along with a grout mixing subsystem, will probably be subcontractor designed, provided, installed, and operated as a complete and integrated system. The grout mixing subsystem is excluded from the scope of this EDF due to the fact that this type of system is already commercially available from multiple vendors. It is not the purpose of this EDF to dictate to prospective subcontractors how to design the instrumentation and controls, or to specify which instrumentation systems or components to use. Prospective subcontractors should find value in the research and analysis developed in this EDF concerning various control concepts, recommended equipment, and methods to achieve the design of a successful integrated system that meets the requirements of the contractor. The process that has been used in the development of this EDF is to list, analyze, and discuss each of the applicable technical and functional requirements that are dependent upon some means of instrumentation and control and to recommend a probable method of achieving success.

Purpose:
The purpose this EDF is to examine the technical and functional requirements for measurements and controls for the ISG Project, and to propose equipment and methods to meet those requirements.

Scope:
Within this EDF, there are six definable systems that have been addressed:

- Grout ingredient storage subsystem
- Grout mixing subsystem
- Grout low-pressure subsystem
- Grout high-pressure subsystem
- Grout injection-positioning subsystem
- Remote monitoring facility.

Primary emphasis is given to addressing the measurement and controls requirements for the last four systems listed above.

Results:
The results of this study is a document that matches the technical and functional requirements with a recommended set of available equipment for selection by the subcontractor in the design effort for instrumentation and data measurement and control systems for the ISG Project.

Conclusions Reached:
1. Off-the-shelf, commercial grade equipment is available to meet the instrumentation and control design requirements.
2. There are areas of concern where research and analysis coupled with lessons learned will be required to optimize the ISG process, but the flexibility of the measurements and control systems as described herein

should make this possible.

Recommendations:
1. The design should include state-of-the-art equipment in measurement and control technology as the primary method to meet the technical and functional requirements with alternate, manual means as a secondary method to continue without stopping the work.
2. It should be a requirement in the performance specification for the design of the measurement and control systems that the design must be submitted for review and approval.

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(See instructions for definitions of terms and significance of signatures.)

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CONTENTS

ACRONYMS

ALARA	as low as reasonably achievable
CFA	Central Facilities Area
COTS	commercial off-the-shelf
DCS	distributed control system
DVR	digital video recorder
EDF	engineering design file
EMWD	environmental measurement-while-drilling
GPS	global positioning system
HD	hard disk
HMI	human machine interface
ICP	Idaho Closure Project
INEEL	Idaho National Engineering and Environmental Laboratory
I/O	input/output
ISG	in situ grouting
MWD	monitoring while drilling
NEC	National Electrical Code
OEM	original equipment manufacturer
OU	operable unit
PLC	programmable logic controller
PTZ	pan, tilt, zoom
RADCON	Radiobiological Control
RMF	Remote Monitoring Facility
RWMC	Radioactive Waste Management Complex
SCADA	supervisory control and data acquisition system
SDA	Subsurface Disposal Area

SSC	structure, system, or component
T&FR	technical and functional requirement
UPS	uninterruptible power supply

OU 7-13/14 In Situ Grouting Project Measurement and Controls

1. PURPOSE

This engineering design file (EDF) will be used as the basis for writing a performance specification for the design of the instrumentation for the measurement and control systems supporting the Operable Unit (OU) 7-13/14 In-Situ Grouting (ISG) Project. As the basis for a specification and to understand project requirements, this EDF provides the design parameter considerations, design codes, and functional requirements for the instrumentation of the various systems comprising the ISG project. This EDF is generated in support of the engineering studies report (ICP/EXT-04-00525 2004) as defined in Guide (GDE)-51, "Construction Project Management Guide," Section I.E. The various devices or components comprising the measurements and controls described in this EDF all fall into the category of commercially available.

2. BACKGROUND

ISG will be performed at the Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA), which is located at the Idaho National Engineering and Environmental Laboratory (INEEL). The SDA is an area of approximately 39 ha (approximately 97 acres) located within RWMC. ISG is a method for injecting grout into the soil for contaminant grouting, which stabilizes the waste in the pits and trenches located in the SDA, or for foundation grouting, which is used for structural foundation enhancement needed for cap installation.

Grouting in the SDA will be conducted with a large hydraulic excavator (i.e., trackhoe) that deploys a roto-percussion drill rig to inject grout into the waste under high pressure. A high-pressure grout pumping system will be integrated with the trackhoe drill. Operations, maintenance, monitoring, and radiation control systems will be deployed to support field operations. A grout supply vendor will be subcontracted to provide grout as specified by the project. It is anticipated that the subcontractor will mix the grout on demand at an onsite batch plant. Grout will be supplied to the high-pressure pumping system by truck.

To minimize the risk of mobilizing contaminants within the waste zone, the company has chosen a single-phase, non-displacement, jet grouting approach, which does not require injection of high-pressure air or free water. This approach drives a drill stem to the bottom of the waste zone, then injects grout at high pressure as the drill stem is removed. During this process, excess grout is returned to the surface along the outside of the drill stem.

The overall magnitude of the ISG project has not bee determined. However, this EDF is based on completing the project in seven years, initially with one operating grout rig and then increasing to three. The final scope may be less.

3. SCOPE

For the purposes of defining the scope of the instrumentation and controls for the OU 7-13/14 ISG Project, the various subsystems comprising the complete ISG system are listed in the following subsections.

3.1 Grout Ingredient Storage Subsystem

Although this subsystem, as well as the grout mixing subsystem , may be functionally performed by means other than providing and mixing the grout at RWMC during 2005, they are included in the scope of this report as if they will be functioning subsystems located at RWMC.

It is assumed the grout ingredient storage subsystem will be designed, fabricated, and operated by the subcontractor. Included in this study is a conceptual design of the measurement and control instrumentation that would be required to control the system and interface with the grout mixing subsystem. Refer to Figure 4 and Figure 5 of Appendix D for a simplified P&ID.

3.2 Grout Mixing Subsystem

It is assumed the grout mixing subsystem will be a commercial off-the-shelf (COTS) system selected by the subcontractor from a vendor that specializes in design and fabrication of this type of equipment. It is further assumed that the size and functions of the grout mixing subsystem will be important factors in the selection of this system. For example, the grout mixing subsystem will be required to control the feed of dry and wet ingredients originating at the grout ingredient storage subsystem. Refer to Figure 5 of Appendix D for a simplified P&ID showing how this subsystem interfaces with the grout ingredient storage subsystem.

3.3 Grout Low-Pressure Subsystem

Within the scope of this engineering study, the grout low-pressure subsystem consists of a low-boy trailer containing a grout hopper, a low-pressure pump, density and flow sensors, piping, and valves. It will also contain a diesel-driven electrical generator and control panel designated as GLPS CP. There are several measurement instruments considered to be essential at the grout low-pressure subsystem: volumetric flow rate of the grout, density of the grout, status of the pump (possibly including the torque delivered by the motor to the pump), and level of grout in the tank. Refer to Figure 6 of Appendix D for a simplified P&ID of this system.

3.4 Grout High-Pressure Subsystem

Within the scope of this engineering study, the grout high-pressure subsystem consists of a truck or trailer bed containing a diesel-powered high-pressure grout pump, drill string parts box, and a control panel designated as GHPS CP. The measurable parameters that are essential to be monitored and trended with respect to the high-pressure pump include vibration status and pressure measurement of the grout at the discharge of the pump. Refer to Figure 6 of Appendix D for a simplified P&ID of this system.

3.5 Grout Injection-Positioning Subsystem

Within the scope of this engineering study, the grout injection-positioning subsystem will consist of a large trackhoe with a drill rig mounted in place of a digging tool. Conceptually, the primary instrumentation researched in this study focused on a Global Positioning System (GPS) integrated into the overall controls of the trackhoe. The GPS includes a local display upon which the operator can view a map of the current trench or pit with the individual hole locations displayed. The operator will also be able to see a moving cursor on the display representing—in real time—the position of the drill stem, providing visual feedback to the operator as the controls of the trackhoe are manipulated. Additionally, as an example of meeting the requirement to monitor and measure the grout returns, the use of a digital video/audio system was researched. Functionally, the trackhoe operator would position and adjust the camera with a pan/tilt/zoom (PTZ) controller and visual monitor to optimize the view and digitize the video record of the drilling and grout injection of each hole. Additional instrumentation required for the trackhoe operator includes visual display of the following parameters:

- Output pressure of the high-pressure pump
- Density of the grout
- RPM of the rotary drill
- Dwell time of the drill at each incremental position of the drill as it is withdrawn
- Volumetric flow rate of the grout.

Refer to Figure 6 of Appendix D for a simplified P&ID of this system.

3.6 Remote Monitoring Facility

Conceptually, the Remote Monitoring Facility (RMF) would consist of a portion of the space in a mobile trailer that can be positioned at various places near the SDA. The purpose of the RMF will be to wirelessly interface with the grout low-pressure subsystem, grout high-pressure subsystem, and grout injection and positioning subsystem and to provide computer-based equipment to monitor and record the measurable parameters at each of those subsystems. There are two systems involved in the RMF: first, a computer-based Supervisory Control and Data Acquisition (SCADA) system to monitor and record the measurable field parameters; and second, a computer-based digital video recording (DVR) system to monitor and record the camera video of the grout returns for each hole. In connection with the SCADA system, there will also be a requirement for Human Machine Interface (HMI) software to configure the measurable parameters and provide trending and alarm screens that would be designed in a detailed design effort. The computer-based digital video system will also require software, and the system recommended in this study as an example includes all of the part numbers for hardware and software required. Refer to Figure 7 in Appendix D for a simplified block diagram of this system.

This study also includes the research and resulting list of hardware that will be required to interface both the SCADA and the video computers with the INEEL intranet using wireless Ethernet communications. It is assumed that Ethernet communications would be established with the INEEL intranet either at RWMC or at Central Facilities Area (CFA), and this would require the installation of a wireless module at one of these locations.

The capability to go online with the ISG SCADA system would expedite the study of the data and provide a convenient method to download the data to a designated INEEL intranet server.

4. REQUIREMENTS

The technical and functional requirements (TFRs) for the ISG Project are listed in the following documents:

- TFR-267, “Requirements for the OU 7-13/14 In Situ Grouting Project (Customer, Project, and System),” which defines those requirements that form the basis for the design criteria delineated in the project EDFs

- TFR-269, "Requirements (Subsystem) for the OU 7-13/14 In Situ Grouting Project," which defines those requirements that were derived from the design criteria contained in the project EDFs.

The process followed in this EDF is to list each of the requirements applicable to the instrumentation and controls, followed by a brief discussion of how each requirement could be met.

All subcontracted services and materials shall be consumer grade (TFR-267, Special Identifier 00048), with the exception of instruments and equipment that generate environmental data, which shall fall into procurement quality level 3

The fact that all structures, systems, and components for this project are ranked as consumer grade, means that all materials, equipment, and components can be consumer grade, or rather, commercially available off-the-shelf equipment (COTS).

A desirable feature would be to provide for high pressure pump continuous monitoring (TFR-269, Item 00181)

It is recommended that instrumentation be installed to continuously monitor the output pressure of the high-pressure pump and the trip relays of a vibration analyzer (see Appendix J and K).

A desirable feature would be to provide for video camera attached to track hoe drill (TFR-269, Item 00182)

It is recommended that a weatherproof camera be mounted on the cab of the trackhoe, rather than on the trackhoe drill. The camera could be utilized for several functions, including monitoring grout returns, training operators, and monitoring ancillary equipment such as the high-pressure pump. If the video equipment–employing wireless technology–that is recommended in this study is utilized, it would be possible to employ multiple cameras and record the video data from each one. The cameras would employ PTZ controls to allow the trackhoe operator or a remote operator in the RMF to adjust for optimum angle, view, and focus (see Appendix F).

Be able to position the drill bit to within plus or minus 1 foot on the surface from the target position (TFR-267, Item 00014, TFR-269, Item 00183)

It would be possible to manually stake out the locations of the prospective holes in all of the pits and trenches in the SDA, and it would probably be relatively simple for the trackhoe operator to position the drill string within ±1 ft of the survey stake. The act of drilling the hole, injecting the grout, and maneuvering the equipment and hoses, combined with the appearance of the resultant grout returns, will work together towards the erasure of where each hole was actually drilled and the grout column created. For these reasons, it is recommended to project management and to the subcontractor that the manual method be considered as a backup to the GPS designed and mounted on the trackhoe. Appendix A provides a more detailed explanation of how the GPS would be implemented and the advantages and benefits to be derived from it for both the subcontractor and the contractor.

A desirable feature would be the capability to reposition the drill bit for the drilling and grouting of the next hole in a short time (target: two minutes or less) (TFR-269, Item 00184)

The use of a GPS to provide feedback to the trackhoe drill operator will reduce the amount of time required to reposition the drill bit for the next hole and mitigate the problem of grout returns obliterating a target flag for the undrilled holes (see Appendix A for a discussion of GPS).

Provide for depth feedback (TFR-267, Item 00016)

This requirement could be met utilizing two different methods:

1. Coordinate with the OEM of the drill rig to provide a vertical position feedback system to the trackhoe operator that includes a convenient digital display with recordable digital signal.

2. Coordinate with the OEM of the GPS equipment to include a roving antenna on the drill rig to provide vertical depth feedback on the GPS monitor. The integration of the drill depth coordinates—as sensed by the drill rig antenna with the other GPS data—will provide an automatic, absolute depth of the drill bit without manually factoring in the varying elevation topography as the trackhoe drill rig traverses the varying sectors of the SDA.

A desirable feature would be the capability to measure the verticality of the drill stem (TFR-269, Item 00186)

This capability could be met utilizing two different methods:

1. Coordinate with the OEM of the drill rig to provide an inclination angle feedback system to the trackhoe operator that includes a large digital display for the trackhoe drill rig operator with auxiliary signal for wireless transmission to the SCADA in the RMF.

2. The subcontractor includes in the design the selection of a COTS inclinometer for mounting on the drill rig. The design would also include the cabling, digital display with auxiliary signal for wireless transmission to the SCADA in the RMF, and recordable signal (see Appendix L for example of available equipment available).

A desirable feature would be the capability to measure grout pressure (TFR-269, Item 00187)

To achieve this capability, the subcontractor would include in the design the selection of a COTS high-pressure transmitter at the discharge of the high-pressure pump. The design would include the required high-pressure fittings, capillary tubing and cabling, and analog or digital display with auxiliary signal for wireless transmission to the SCADA in the RMF. The large digital display would be installed for easy viewing by the high-pressure pump operator. The trackhoe drill rig operator would also require a large digital display representing the high pressure. Access to this signal can be acquired wirelessly as relayed by the SCADA system at the RMF.

During the development of this EDF, there have been discussions about the feasibility of locating a high-pressure sensor/transmitter at the swivel fitting on the drill rig to monitor the pressure of the grout closer to the injection nozzles in the drill bit. If this were done, it would provide pressure drop data that develops in the high-pressure grout hose when the signal is compared to the pressure at the discharge of the high-pressure pump. This scenario is feasible and there is COTS equipment available, as mentioned above, to accomplish this (see Appendix J for example of equipment available).

A desirable feature will be the capability to measure grout flow (TFR-269, Item 00188)

It is recommended that the subcontractor include in the design the selection of a Coriolis flow sensor in the discharge piping of the low-pressure grout feed pump. The Coriolis flow sensor includes a transmitter with visual display of the sensor parameters, including volumetric flow in selectable engineering units. The Coriolis transmitter would be mounted in the door of the control panel located at the grout low-pressure subsystem trailer. The Coriolis transmitter provides selectable auxiliary signals for wirelessly transmitting to the SCADA in the RMF for trending and recording. This signal could also be wirelessly transmitted to a large digital display located in the trackhoe drill rig cab for operator feedback.

Be able to measure grout volume (TFR-269, Section 3.8)

Coriolis sensors have been designed and developed to measure three parameters with high precision accuracy: Volumetric flow rate, density, and total volumetric flow. The requirement “to measure grout volume” is interpreted to mean: “measure the grout volume for each hole.” The Coriolis transmitter is designed to be configured to display and retransmit the named parameters. The transmitter also has the capability to have its total volumetric flow counter reset when required. This would simplify recording the total volumetric flow in selectable engineering units for each hole drilled and grouted. The “volume reset” function could be performed by the trackhoe drill rig operator by pushing a button in the trackhoe cab that is wirelessly transmitted to the Coriolis transmitter at the grout low-pressure subsystem control panel. In the same manner, the flow and density signal parameters can be transmitted and displayed to the trackhoe drill rig operator in the trackhoe cab. Appendix G provides a discussion of the purpose for monitoring the volumetric flow of grout. Appendix H provides a discussion of Coriolis sensors and why it is the preferred method to measure instantaneous volumetric flow rate and total volumetric flow of grout.

Be able to measure grout returns (TFR-267, Item 00019)

This requirement can be accomplished in at least two conceivable methods. One method would employ video images digitally recorded during the drilling and grouting of each hole. If the camera is properly positioned and controlled, digital video signals at a streaming rate of 5 frames per second would record the grout returns and provide data that will enable an acceptable estimate of the total grout returns for each hole. This method will require some refinements based on actual testing and measurement of grout returns to establish the bounds of accuracy to be derived from the digital images. For additional information concerning a digital video recording system, see Appendix F and Fig 7 in Appendix D.

A second method would be by personal visual observation and note-taking for each hole. This method will also require some refinements based on actual testing and measurement of grout returns to establish the bounds of accuracy.

It is recommended that the digital video method be used as the primary method and the manual method would be a secondary backup procedure.

A desirable feature is that the system be designed to facilitate a recovery from an emergency shutdown

During off-normal operations, probably the most critical parameter to monitor is the output pressure of the high-pressure grout pump. If the high-pressure limit is exceeded, the high-pressure pump should be shut down. EDF-5102, Section 4.1 states that “the controls for the grout pump will be designed to automatically shut off the grout pump when the line pressure exceeds the maximum operating pressure of 8,000 PSI.” Even though this capability is included in the standard controls of the pump, it is recommended that the output pressure of the high-pressure pump be continuously monitored and recorded for purposes of trending to diagnose the dynamics of jet nozzle wear.

If an event such as this occurs, the design of the system should include programming and provision for saving and securing data, as well as assuring that a restart of the system can only be accomplished manually in accordance with a defined procedure.

A desirable feature is that the system be designed to interface with data management components

This feature would include the capability of the data control system to communicate with the INEEL intranet system for the purposes of management review and the transfer and storage of data files on a designated server.

The system should be designed to provide for wireless Ethernet communication between the SCADA system located in the RMF outside the SDA boundary and the INEEL intranet (see Appendix N).

A desirable feature is that the system be designed to interface with data collection components

The system should be designed to include equipment and devices to measure and monitor field data and wirelessly transmit the data signals to a SCADA that includes an HMI console and a programmable logic controller located in the RMF outside the SDA boundary (see Appendix N).

Provide for radiological monitoring (TFR-267, Items 00002 and 00036)

Consultation with Mr. Rick Horne of RWMC Radiological Engineering concerning the lessons learned during the Phase 1 beryllium block wax injection project (2004) leads to the following recommendations:

- There will be no requirement to scan or frisk the drill stem for radioactive contamination after withdrawal from each hole unless the drill stem requires some sort of inspection or maintenance activity to be performed by personnel in close proximity to the drill rig or in the event the drill rig has to make an excursion outside of the trench or pit. The RWMC Radiological Engineering organization will be available to advise in the mounting of the detectors and the subsequent monitoring activities.

- When personnel have to come in close proximity to the drill rig, there are two types of gamma detectors that should be mounted on the structure of the drill rig to scan the drill stem for radioactive contamination.

- The Radiological Engineering organization has electrically powered gamma detectors that can be mounted on the drill rig structure. An electrical power cable will have to be installed along the trackhoe stick and boom to the electrical generator on board the trackhoe. The cable will have to be installed and managed in a similar fashion to the high-pressure grout hose, with tensioners, pulleys, etc. The unit has audible and visual alarms if contamination thresholds are exceeded.

- For approximately $20,000, battery-powered units are available that can be mounted on the drill rig. The unit would wirelessly transmit the milliroentgen per hour reading to a remote laptop computer. The software can be configured to provide alarms to the laptop if contamination thresholds are exceeded.

Provide for industrial health monitoring – air monitoring (TFR-267, Items 00003 and 00036)

The RWMC safety and health organization will provide logistical support in the acquisition and setup of air sampling and monitoring system, as well as training subcontractor personnel in the use of the equipment.

The contractor could assist the subcontractor in setting up the monitors, and in calibrating and positioning the equipment. Training will be provided to the subcontractor on actions to take in the event of an alarm. There will be no requirement for this equipment to tie-in to any existing, external alarm systems.

Consideration should be given to the possibility that continuous monitoring may be required in the trackhoe cab.

A desirable feature is to provide level sensing for dry mix tank (grout ingredient storage subsystem)

It is recommended that the design of the grout ingredient storage subsystem include the capability to continuously measure the level in the dry ingredient storage silos. The grout ingredient storage subsystem may consist of up to five silos for receipt and storage of several dry ingredients including sand, cement, blast furnace slag, and silica fume.

Level detection in the dry ingredient silos is much more difficult than in liquid or slurry tanks. The angle of repose of the material—which is unique for each material and varies depending upon the amount of moisture in the material—the amount of dust, height of the silo, degree of compaction, etc., all are factors that will influence the decision as to which device to select to monitor the level.

In general, for dry materials, it is recommended that a radar type of instrument be used (see http://www.milltronics.com/product/product.asp?cfc=7ML5421 for a technical description of a Sitrons - Milltronics LR 400 instrument that utilizes radar technology and http://www.milltronics.com/pdf/catalog/7ML19955FH01.pdf for a technical data sheet on this particular device).

Radiological – provide portable personnel airborne monitoring equipment (TFR 267, Items 00002 and 00036)

The monitoring equipment will be identified, the project will provide the procurement funding for the equipment, and procurement will be accomplished by the RWMC radiological organization. Some of the equipment will require 110-VAC power with a maximum of 24 (startup) amperes and a running FLC of approximately 5 to 7 amperes. Approximately five 110-VAC receptacles will be provided by the contractor in the vicinity of the hole drilling and grout injection operation.

The radiological equipment will be managed by the RWMC radiological organization, which will set up the equipment and monitor its operation.

Radiological – provide portable personnel exposure monitoring equipment (TFR-267, Items 00003 and 00036)

There are four general classifications of radiological instruments that will be utilized in this project:

1. Radiological airborne monitoring equipment
2. General area radiation monitoring equipment (beta, gamma, and neutron)
3. Radiological contamination monitoring equipment
4. Personnel radiological contamination monitoring equipment.

The project will provide the procurement funding for the equipment and procurement will be accomplished by the RWMC radiological organization. Some of the equipment will require 110-VAC power with a maximum of 24 (startup) amperes and a running FLC of approximately 5 to 7 amperes. Approximately five 110-VAC receptacles will be provided by the contractor in the vicinity of the hole drilling and grout injection operation.

The radiological equipment will be managed by the RWMC radiological organization, which will set up the equipment and monitor its operation.

There will be no requirement for the subcontractor to be involved in the operation or maintenance of this equipment.

5. SYSTEM CLASSIFICATIONS

In general, the safety category for this project has been classified as consumer grade; however, with respect to any instrumentation that interfaces with the high-pressure grout, it is assumed to have a safety classification of “safety significant” due to the 10,000-psi maximum rated working pressure (see EDF-5102, section 5).

6. ASSUMPTIONS

1. The individual subsystems will all be subcontractor designed and installed and operated on a subcontract basis.
2. The data derived from field instrumentation will be wirelessly transmitted to a SCADA system located outside the SDA fence in a mobile trailer (RMF).
3. Project management will require that wireless intranet communications will be the means of maintaining on-line connectivity and management of the accumulated data derived from the measurement and controls system.
4. 110-VAC power will be available at the grout low-pressure subsystem, grout high-pressure subsystem, grout injection positioning subsystem, grout ingredient storage subsystem, and RMF in the mobile trailer.
5. The grout ingredient storage subsystem will be designed and installed by the subcontractor at RWMC.

7. DESIGN CRITERIA

7.1 Applicable Design Codes

The design of the measurement and controls system shall be in accordance with the applicable sections of the National Electrical Code (NFPA 70, 2002 edition) and ANSI/ISA-S5.1.

7.2 System Design Requirements and Objectives

7.2.1 Desired Features and Design Requirements for Measurements and Control Systems

1. A major concern and emphasis imposed by management upon the designers of the measurement and control system is to conceive and proceed with a design that is as practical and simple as possible, while not necessarily avoiding state-of-the-art electronic equipment. The purpose here is to maximize efficiency in terms of drilling and grouting as many holes per day as possible while doing it safely; capturing, recording, and verifying the accumulated data for analysis; and developing in-situ grouting processes.

2. Another consideration is redundancy in the system, to the extent that even a failure of the SCADA system would not necessarily shut down the ISG operation. Specifically, the design should take into account that if any system or system component fails, grouting can or should continue while emergency repairs proceed in parallel. This will necessitate some design planning concerning the implementation of temporary manual methods in substituting for the automated functions of the electronic systems.

3. Desired features that should be considered include the capabilities to sense the angle of inclination of the drill bit and to measure the instantaneous volumetric flow rate and total volumetric flow of the grout injected into each hole. For example, it is known that there is relatively large, cylindrical, carbon-steel containers buried in some of the trenches. The orientation of these containers is unknown. While drilling a hole, if the drill bit encounters a cylinder surface at an oblique angle, it could be deflected along the cylinder surface and, as a result, not penetrate into the container. The capability to measure the deflection angle of the drill bit, as imposed upon the drill rig structure, would serve to alert the operator to an unusual condition that would otherwise go undetected. The unusual condition alluded to in this example would be the failure of the system to inject grout into the void of the cylindrical container—an undesirable event.

   It is postulated that if the system can measure the angle of tilt from the vertical and/or the force imposed by the diversion of the drill stem, it may be possible to consistently predict when penetration of a solid container has not been achieved. When this happens, the procedure might be the withdrawal of the drill stem to affix a different design of cutting bit and a subsequent attempt to drill into the container, either in the same hole or at a different position.

4. As described in paragraph 3 above, the capability of the system to measure the instantaneous volumetric flow rate and the total volumetric flow of the grout injected into each hole would also be a desirable feature. Consider the same cylindrical containers in the previous example. If the drill bit is successful in penetrating the cylinder, the capability of the system to measure instantaneous volumetric flow rate and total

volumetric flow will serve to alert the operator that, possibly, a void has been encountered because the volumetric flow rate should rise as well as the total volume of grout injected into the hole. This sort of data could diagnose underground soil conditions as well as confirm the presence of voids such as would exist in large waste containers.

If the system can measure the instantaneous rate of flow of the grout, the total volumetric flow of the grout into each hole, and the capability of approximating the volume of grout returns to the surface, this could lead to the conclusion that the penetration of a large container has been successful and would explain why a larger volume of grout than expected has been injected into a hole.

7.2.2 Maximizing System Reliability

1. All components of the measurement and control system shall be commercially available equipment, of proven technology, and available off the shelf or of relatively short-term delivery.

2. Redundancy is considered extremely important. For example, uninterruptible power supply (UPS) for the SCADA and video equipment within the RMF, critical spare parts on hand, and trained personnel who can troubleshoot and diagnose the systems. This does not mean that unpredicted downtime must never be allowed to occur. What it does mean is that when a system component does fail, the impact of the failure is minimized and there is a plan for proceeding with the grout injection process, if at all possible, until the component or subsystem is repaired.

3. It is recommended that the performance specification be worded to include a requirement that only a certain, minimal percentage of the total grouted holes will be allowed without electronic verification of data. The data of concern is all of the data accumulated in the course of drilling a hole and injecting the grout. The concern here is that after the holes are drilled and grouted, and the subcontractor is gone, the result of all of this work and expense could be a waste area that has been penetrated with unknown amounts of grout, no records of how individual grout columns interfaced with the buried waste, and uncertainty of the hole locations and their inclination angles.

8. RISKS

8.1 Equipment Failure

8.1.1 Failure of Global Positioning System Components

State-of-the-art GPS equipment is mature and very reliable and is getting better all the time. Although GPS and trackhoe equipment could be ordered separately by the subcontractor and subsequently integrated into a workable system, it is recommended that the trackhoe and GPS be acquired as a fully integrated package and warranted by the manufacturer to meet the requirements. To mitigate GPS component or system failure, it is recommended that the subcontractor negotiate a contract with the supplier of the trackhoe to provide an integrated package composed of the trackhoe, drill rig, and an integrated GPS with training and an on-call technical support agreement. (Note: GPS equipment is COTS and very mature, but to involve the GPS manufacturer in the design of a system to be installed and integrated into the trackhoe and drill rig controls makes very good sense because they are experienced in doing it. GPS manufacturers are typically anxious to get involved because they have the experience and know-how and have a vested interest in the success of the project.)

With a standby GPS rover antenna, a failure of the trackhoe/GPS would not result in a work stoppage. Although it would require that a person to hand carry the rover antenna into the SDA, if permitted by RADCON, for manual determination of the next series of holes, this manual procedure could proceed until emergency repairs of the main system are completed.

8.1.2 Failure of Video Camera or Any of the Video System Ancillary Equipment

Although it is a recommendation of this study that a DVR system be implemented for the purpose of documenting the grout returns for each hole drilled in the SDA, a failure of this system need not stop the work. Spare components should be on hand to get the system functioning quickly; but in the meantime, this task could be performed manually by careful observation, hand-held video cameras with telephoto lenses, and/or hand-held digital cameras and field notes.

8.1.3 Failure of Supervisory Control and Data Acquisition System Components

A failure of this system need not stop work. The main function of the SCADA is to monitor and record the field data as efficiently as possible. With the use of field instruments (i.e., transmitters with local indicators), manual observation and field notes would mitigate the impact of a system failure until emergency repairs are completed.

8.2 Operational and Maintenance Training and Testing

There is no substitute for well-trained operations and maintenance personnel. Since the assumption is that the equipment and personnel for this project will be a subcontractor responsibility, it will be incumbent upon and in the best interests of the subcontractor to be as prepared as possible in terms of training for the workers.

The Cold Test Pit – North will be used for operational training and an operational checkout of the grout low-pressure subsystem, grout high-pressure subsystem, and grout injection and positioning subsystem. This will also include training on the RMF (Remote Monitoring Facility) located in a mobile trailer outside the fence of the SDA.

The subcontractor will design the various subsystems, including hardware and software and wireless communication equipment to function together as a complete, integrated system.

One of the requirements of the performance specification will be the submission by the subcontractor of a system testing procedure. This procedure will include a step-by-step method of testing each device and component of each subsystem, including the testing of the wireless communication equipment. After the testing procedure has been reviewed and approved, an operational test would commence at the Cold Test Pit – North.

9. LOGISTICS SUPPORT

From the perspective of the measurement and control systems conceptually defined in this study, the logistics support required would consist primarily of the following:

1. The RMF will require reliable 110-VAC power with UPS.

2. The RMF will require air conditioning.

3. The SCADA and video equipment in the RMF will require fairly consistent operator attention.

4. The measurements and controls equipment located in the grout low-pressure subsystem, grout high-pressure subsystem, and grout injection positioning subsystem will require clean and consistent electrical power. In general, the utilization voltage for the instrumentation referred to in this study is 12 or 24 VDC. In most cases, this voltage is derived internally in each instrument from internal DC power supplies with 110 VAC input power requirements. For instrumentation without internal power supplies, the subcontractor will include in the design the provision for DC power supplies in the control cabinets.

5. 110 VAC electrical power for the grout low-pressure subsystem and grout high-pressure subsystem will be provided by a diesel-electric generator mounted on the grout low-pressure subsystem trailer. The subcontractor will include in the design the provision for the installation of power circuits fed from this generator to the control panels for these two subsystems.

6. 110 VAC electrical power for the grout injection and positioning subsystem instrumentation will be provided by an electric generator on board the trackhoe. The subcontractor will include in the design the provision for the installation of power circuits fed from this generator to the control panel and instrumentation systems on board the trackhoe.

7. The RWMC radiological organization will provide logistical support in the acquisition and setup of the radiological equipment and the monitoring of the same. They will also provide training to subcontractor personnel in the use of the equipment. Electrical power outlets providing 110 VAC power will be required to power this equipment.

8. RWMC safety and health organization will provide logistical support in the acquisition and setup of air sampling and monitoring system, as well as training to subcontractor personnel in the use of the equipment. 110 VAC power will be required to power this equipment.

10. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

This study has endeavored to examine and research all of the technical and functional requirements imposed upon the measurement and control functions as well as desirable features in the measurement and control domain that have been discussed or considered in this project.

Consideration should be given to a study to identify the lifecycle cost difference between full instrumentation versus manual methods to collect, analyze, and store data. A fully developed lifecycle cost analysis was not within the scope of this EDF. Good instrumentation will result in reliable and timely data presented in such a way as to be useful when needed.

It is acknowledged that there are many different techniques that could be used in terms of equipment and design philosophy to accomplish or meet the requirements for measurement and control. For example, in the case of measuring the grout returns, this could be done manually with an operator dedicated to the task of mentally estimating the amount of grout returns for each hole and making an entry onto a form. This is the secondary method. The primary method, in the view of this study, will be to employ computerized video equipment that can digitally capture the video record of the drilling and grout injection sequence of each hole to provide a means to estimate the volume of grout returns for subsequent examination and study. This method will also give the trackhoe operator the opportunity to add audible or oral data that will be pertinent to each hole as it is personally observed. The cost of the digital video system hardware is in the neighborhood of $30,000. It is recommended that careful consideration be given to this method for accumulating data records relative to estimating grout returns. The capital cost of digital video equipment compared to the cost of augmenting the operations staff to accomplish this task manually is a reasonable investment. This is especially true when this reasoning is applied to a project that is scheduled to operate from five to seven years with multiple shifts and multiple drill rigs operating simultaneously.

Another example is the use of GPS integrated with online real-time process data from the high-pressure pump and drill-rig parameters. It has been suggested that this kind of equipment for this project may be extravagant or unnecessary. When the savings in time and the value of good data derived from utilizing a GPS, and real-time process data are weighed against a control process that depends upon manual data collection methods, the positive benefits should be obvious to the subcontractor and to the contractor and could make the difference between a failed or successful project.

Consider the procedure that must be accomplished if all of the surveying, staking, and data entry related to each hole is to be done manually:

1. Each hole must be given a tag name or number and listed on field notes or possibly in a computer spreadsheet file that is created for each pit or trench.

2. The coordinates of each hole must be determined individually by separate survey either with conventional pre-GPS methods or a GPS roving antenna that is used only to establish the hole coordinates.

3. The coordinate data must be either manually entered into the field note record or in the correct spreadsheet file. (If a hand-carried GPS roving antenna is used, it has the capability of collecting each hole-coordinate data set as a "way point" that could be downloaded into the spreadsheet file.)

4. Each hole will have to be staked with its tag number.

5. When the drilling begins, an observer with clipboard, laptop, or PDA in hand must be present to observe the drilling and grout injection operation and manually enter the data as each hole is drilled and grouted.

6. The same observer or another observer must also watch and estimate the volume of grout returns that occur for each hole and enter that data into the field notes.

7. The observer must obtain grout volume data for each hole by checking the stroke counter on the high-pressure pump, taking care to get the counter readings before and after the grouting of each hole.

8. The first reading must be subtracted from the second reading to get the actual stroke count.

9. Depending upon prior field tests, a multiplier must be applied to the stroke count to arrive at the estimated volume of grout for each hole.

10. Lessons learned from the Phase 1 (beryllium block – wax injection) Project (2004) indicate that grout returns in volumes much greater than expected were experienced. It is speculated that the cause for the increased volumes of grout returns is because of compaction of the overburden soil in years subsequent to flooding of the SDA in high-water years. Whatever the root cause in the case

of Phase I, similar problems should be anticipated in Phase II (In situ grouting of the SDA), only compounded in severity by the fact that Phase II will employ cementacious grout instead of hot wax grout as was used in Phase I. The use of cementacious grout will result in faster erosion of the grout jet orifices. Erosion or plugging of the jet orifices is important to note because there must be some method of tracking the erosion or detecting the plugging of the jet orifices. If this is to be done manually, it will require continual close scrutiny, analysis, and comparison of the output pressure of the high-pressure grout pump, grout density, volume of grout injected for each hole, and volume of grout returns for each hole. If no effort is made to manually record and analyze the data, the only way to check the erosion of the orifice jets is physical inspection. This will require frequent pauses in the drilling and grout injection process to frisk the drill stem to check for plugging or erosion and decide the course of corrective action.

11. Use of manual methods of observation and data collection mean the trackhoe operator, the GHPS operator, and the grout returns observer are faced with the need to keep track of the volumetric flow of grout into each hole.

12. As the grout jet orifices erode, the volumetric flow rate of grout will increase. This increased volumetric flow rate must be compensated for by an increase in rotational speed and lift rate of the jet bit in order that each hole receives the same total volume of grout.

13. The grout high-pressure subsystem operator will have to increase the throttle setting on the diesel engine driving the pump to maintain uniform pressure as this orifice wear progresses.

14. Since all of these changes and fluctuations are being observed manually, it will require very close coordination between the various operators and may, in fact, be impossible without each operator having access to visual displays that update the process parameters in real time.

15. Changes in grout density have a significant effect on volumetric flow rate at a given pressure and jet orifice diameter. Changes in this parameter will necessitate that the grout high-pressure subsystem operator make compensating adjustments in the throttle and adjustment gears to maintain uniform pressure. Assuming, in this scenario, that no means for online, real-time density measurement is available, operations will be blind to variations in this critical parameter and probably will not be able to compensate for it.

16. The trackhoe operator will probably call for increased pressure when encountering very hard soil formations where grout returns become more fluid than normal (an indication that the jets are unable to fully penetrate the soil).

17. Either the trackhoe operator or the observer must concentrate on the depth of the drill bit during the drilling operation and when the grout is being injected during drill withdrawal. This data must be manually logged into the field notes.

18. The final estimated volume of grout is entered and applied against the correct hole on the field notes. (Note: If a Coriolis flow sensor is used in conjunction with or instead of a stroke counter on the high-pressure pump, the data from the flow sensor transmitter must be read by the observer and entered into the field notes unless this data is sent to a SCADA for display and recording of data.)

19. Assuming that all of the holes for each pit or trench are staked out before the drilling and grout injection process begins, there will be an array of stakes possibly numbering into the hundreds or even thousands, depending upon the size of the trench. (Historically, trying to maneuver and position heavy equipment within or in the vicinity of a staked field will result in broken or buried

stakes.) If this happens, it will require resurveying and restaking the holes or attempting to estimate the correct hole locations.

20. Manually surveying and staking the holes in the beginning or restaking subsequently (if some are lost) will require people walking around and working on the overburden area of the pits and trenches. This is probably going to result in unacceptable radiation exposures and would not be in accordance with As Low As Reasonably Achievable principles.

Contrast the manual example above with the recommended system where the trackhoe is outfitted with a GPS that is integrated into the trackhoe hydraulic controls, and the high-pressure pump and drill rig are instrumented to give current, real-time process data that is presented to the various operators in highly visible displays:

1. The trackhoe operator has a GPS monitor screen in the trackhoe cab on which is displayed the outline boundaries of the pit or trench. Also displayed is the location and identification of each prospective hole to be drilled. As the operator maneuvers the trackhoe arms and drill rig, the position of the drill bit is shown in real-time as a moving cursor (similar to a mouse pointer) on the GPS screen. The operator's task will be to utilize feedback from the GPS monitor screen to position the drill bit over the coordinates of the target hole and begin drilling. Once drilling begins, the operator can observe the depth of the drill bit from real-time feed back on the GPS monitor screen.

2. When the target depth is reached, the operator will either push a button or signal to an operator at the grout high-pressure subsystem to increase the flow of grout from a "trickle mode" that provides lubrication while drilling to an "injection mode" that forms a grout column as the drill stem is withdrawn.

3. As the drill bit is withdrawn from the hole, grout is injected through orifices in the drill bit.

4. If a Coriolis flow meter is used, the volumetric flow rate and density of the grout will be monitored, recorded, and displayed to the trackhoe-drill rig operator, to the grout high-pressure subsystem operator, and on a monitor at the SCADA location in the RMF.

5. Since rapid erosion of the drill bit orifices, variable grout density, and variable soil formations are expected, compensation for these process variations will be enabled by a system that continuously tracks each variable and presents enough data simultaneously to each operator so that quick and intelligent decisions can be made.

To quote from Mr. Ernie Carter of Carter Technologies Co., (email: cartertech@prodigy.net) in an email dated August 1, 2004:

"The drill operator must have highly visible readouts of pump pressure, grout density, RPM, dwell time, and grout flow rate. He must also have charts or preferably an excel spreadsheet in a pocket computer, that provide him with the corrected jetting parameters as the jets wear and the flow rate increases. These readings as well as the video and audio feed must also be displayed in the data/control (RMF) so that operations can be monitored in real-time by the grouting engineer. The drill operator, the pump operator, the grouting engineer, and the grout tank tender should be in constant radio communication with noise canceling headsets. There should be no private communications that are not fed to the data/control trailer (RMF) and recorded."

This recommendation by Mr. Carter, along with others from him included in the example scenarios above, are endorsed as conclusions by this EDF.

11. REFERENCES

EDF-5102, “OU 7-13/14 In Situ Grouting Project Grout Delivery System

GDE-51, “Construction Project Management Guide”

National Electric Code

TFR-267, “Requirements for the OU 7-13/14 In Situ Grouting Project (Customer, Project, and System)”

TFR-269, “Requirements (Subsystem) for the OU 7-13/14 In Situ Grouting Project”

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Appendix A

Global Position System Control Feedback

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Appendix A

Global Position System Control Feedback

There are various methods that could be utilized to identify the locations where each of the holes in the trenches and pits should be drilled. The drill hole pattern has been specified to be parallel rows of holes laid out orthogonaly to the long line of the trench or pit. The parallel rows of holes will be 20 inches apart, and the holes in each row will be 20 inches center to center. Alternate rows will be offset 10 inches so that the hole-pattern will assume a triangular pattern. Another requirement is that each row of holes will bridge across the pit or trench by approximately 18 inches (i.e., the outlying holes in each row will be drilled in the adjacent ground surrounding the trench or pit). Appendix B provides a description of Cold Test Pit – North and it use as an ISG test area. Figure 3 in Appendix D provides an illustration of Cold Test Pit – North and a coordinate table.

The result of the above requirement will be that there will be a large number of holes, the depth of which will range from 18 to 26 feet.

The purpose in drilling the holes is to inject fluid grout at high pressure to form grout columns approximately 24 inches in diameter that extend from the bottom of the pit or trench up to near the surface of the ground. These grout columns will comprise, when complete, a monolithic structure beneath the ground to stabilize and contain the waste as well as to create a structure strong enough to carry the burden of a large earthen cap that will overlay the existing ground surface of the entire SDA. It is expected that this resultant grout monolith and cap will be able to endure at least 1000 years.

Since there is a very large quantity of holes, it is important to design a system that can identify the location of each prospective hole and do it as quickly as possible while at the same time recording data parameters that are unique to each hole. Present day technology offers a method to do that in the utilization of GPS (Global Position System) equipment. The concept is as follows:

- Utilizing survey data that defines the boundaries of each pit or trench, calculate the positions of each hole in terms of its “Northing” and “Easting” coordinates.

- Create an AutoCad drawing of each pit and trench, assign each hole a tag number and indicate its location on the drawing.

- Create a .txt file representing each hole-coordinate. (There are conversion schemes that make this a relatively easy task.)

- Download the “.txt” file into the GPS monitor and controller. This will result in a graphic on the GPS monitor that will display the position of each hole in a specific pit or soil vault row.

- Establish the coordinates for a base reference GPS antenna that will communicate via radio signal to the GPS main controller located in the trackhoe cab. (The purpose of the base reference antenna is to correct the constantly changing coordinate data and reduce the error to an insignificant level. Test data has proven that the accuracy is within one centimeter.)

- There are excavation equipment companies such as Caterpillar Equipment that have established a working partnership with GPS manufacturers: Trimble. (Headquarters: 749 North Mary Avenue, Sunnyvale, CA 94086), (www.trimble.com)

- Caterpillar Equipment also has partnered with TOPCON Positioning Systems, Inc., http://www.topcon.com/, 5758 W. Las Positas Blvd, Pleasanton, CA 94588, Tel: (208) 870-5879, email: mlodge@topcon.com (Murray Lodge – National Sales Manager)

- An interesting fact is that Caterpillar Equipment, in partnering with TOPCON and Trimble, has developed systems that consist of a large trackhoe with a digging tool or some alternative device mounted in place of the digging tool. The roving antenna (there could be multiple antennas) is mounted near the counterweight on the trackhoe structure, and feedback signals derived from the beam and stick movements result in real-time, precise X, Y, and Z coordinates of the digging tool. With an additional GPS antenna mounted on the top of the drill stem so that it moves vertically, all the feedback the trackhoe operator will need in terms of X, Y, and Z coordinates for the drill bit are available on the GPS monitor in real time.

- With the GPS fully operational, the trackhoe operator will be able to see on the GPS monitor the location and elevation of the drill bit in relation to the hole coordinates as the drill bit is maneuvered above the pit or soil vault row where the holes are to be drilled.

- The main GPS monitor has non-volatile storage capability in the form of a memory flash card that will accumulate data for hundreds of holes. The flash card can be removed periodically and inserted into a flash card portal linked via a USB port to a computer workstation for storage locally or transfer via wireless Ethernet to a designated server.

Appendix B

Cold Test Pit – North To Provide Initial Testing Area for the In Situ Grouting System

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Appendix B

Cold Test Pit – North To Provide Initial Testing Area for the In Situ Grouting System

The Cold Test Pit – North is a surrogate pit constructed and prepared to test in situ grouting technology before the Pit 9 project was envisioned. It has been prepared with five separate levels of surrogate waste embedded in a pit that is 18-ft square, and 18-ft 9-in. deep. The waste seam is comprised of five layers of simulated waste positioned to simulate a modified random dump configuration. (Please see EDF-ER-199 for information about the construction of this pit and details of the waste contained therein.) Figure 3 in Appendix D has been prepared to accurately represent the physical location of the Cold Test Pit – North and the location of the holes to be drilled and filled with grout injected at high pressure with the trackhoe-mounted drill rig.

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Appendix C

Radioactive Waste Management Complex Subsurface Disposal Area Survey Data and Discussion

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Appendix C

Radioactive Waste Management Complex Subsurface Disposal Area Survey Data and Discussion

Reference to Figures 1 and 2 in Appendix D.

Figure 1 in Appendix D is a simplified layout of the various pits, trenches and soil vault rows in the SDA. The "Sequence Table" on Figure 1 lists the priority order that will be followed in the grout injection schedule beginning in 2005. These areas contain actual radioactive waste. An ongoing study is proceeding to improve the accuracy of the boundaries of these areas. The problem is that various factors, such as flooding of the SDA during high-water years, has resulted in the conclusion that the boundaries are not necessarily sharp, straight lines.

Reference: "DOE-ID ARCHITECTURAL ENGINEERING STANDARDS", surveying control on the INEEL, Appendix J: (http://www.inel.gov/publicdocuments/doe/archeng-standards/pdf/Aem-appj.pdf)

Reference: Drawing 416511, sheets 1 and 2, entitled: Radioactive Waste Management Complex Diagram.

The survey data for the SDA at the INEEL RWMC, as illustrated in reference drawings 416511, sheets 1 and 2 (see Appendix D), is based on what is known as "RWMC Project coordinates." Drawing 416511 is a graphical representation of the entire RWMC complex including the SDA. The SDA has been subdivided into 58 trenches numbered consecutively from 1 to 58, and 21 pits numbered 1 through 20 with one pit entitled, "Acid Pit."

The trenches and pits have been resurveyed in recent years with GPS equipment and the data for this work are based on NAD83. The following list is a textual copy of a printout of that file, and an electronic version will be provided to the subcontractor in the performance specification.

;SOFTWARE: Corpscon for Windows 5.11.08

;Horizontal Datum: State Plane, NAD83

;Horizontal Zone: Idaho East - 1101

;Horizontal Units: U.S. Survey Feet

100,668393.31107,423926.11278,SVR1E

101,668406.14096,423897.04286,SVR1W

102,668391.31106,423925.12276,SVR2E

103,668404.12094,423893.06284,SVR2W

104,668387.30106,423923.15273,SVR3E

105,668400.12095,423894.08281,SVR3W

106,668383.29106,423922.17269,SVR4E

107,668396.10094,423890.11278,SVR4W

108,668381.29106,423921.18268,SVR5E

109,668393.12095,423891.12276,SVR5W

110,668963.31732,422929.72664,SVR6E

111,669107.17589,422536.79751,SVR6W

112,669234.38093,421125.99747,SVR7E

113,669327.02007,420888.52805,SVR7W

114,668959.71733,422928.66662,SVR8E

115,669103.14589,422537.11748,SVR8W

116,669322.83393,422001.26886,SVR9E

117,669355.10198,421434.04854,SVR9W

118,669361.26397,421999.08891,SVR10E

119,669377.72304,421725.06873,SVR10W

120,668953.57732,422927.18656,SVR11E

121,669068.77617,422612.60726,SVR11W

122,668397.04091,423880.10278,SVR12E

123,668702.45796,423076.55463,SVR12W

124,669362.05818,423206.82971,SVR13E

125,669376.41718,422915.80950,SVR13W

126,668950.11732,422926.21653,SVR14E

127,669063.47619,422616.97722,SVR14W

128,669375.41718,422915.81950,SVR15E

129,669411.13459,422157.08900,SVR15W

130,669382.38720,422918.85950,SVR16E

131,669426.46409,422007.71889,SVR16W

132,669356.08198,421433.23854,SVR17E

133,669387.86015,420896.88818,SVR17W

134,668944.56732,422926.23648,SVR18E

135,669059.76617,422610.65718,SVR18W

136,668208.04097,423870.16124,SVR19E

137,668716.13608,422537.38434,SVR19W

138,668200.03097,423869.21118,SVR20E

139,668709.61606,422532.45428,SVR20W

140,668940.33732,422924.69645,SVR21E

141,669055.53617,422609.10714,SVR21W

142,669789.26746,422805.34925,PADANW

143,669780.84830,423045.14940,PADANE

144,669446.13771,423033.40955,PADASE

145,669454.54688,422793.60939,PADASW

146,669826.48472,422008.83878,TR1E

147,669620.51043,420879.08814,TR1W

148,669281.48394,422000.13851,TR2E

149,669348.93010,420896.82818,TR2W

150,669338.29394,422002.35892,TR3E

151,669404.74017,420893.39818,TR3W

152,669384.77401,422004.25890,TR4E

153,669457.09023,420889.90816,TR4W

154,669796.30475,422029.78880,TR5E

155,669603.81042,420880.21815,TR5W

156,669409.26406,422005.22890,TR6E

157,669474.37025,420888.67816,TR6W

158,669763.75469,422027.83881,TR7E

159,669584.00039,420881.50815,TR7W

160,669450.26412,422003.58889,TR8E

161,669509.98029,420886.49815,TR8W

162,669718.15461,422024.69883,TR9E

163,669565.04036,420882.79815,TR9W

164,669461.38421,422023.52890,TR10E

165,669522.87025,420869.42814,TR10W

166,669225.52404,422020.89807,TR11E

167,669273.85094,421134.08780,TR11W

168,668579.59748,422918.28352,TR12E

169,669204.06136,421245.13732,TR12W

170,669209.34400,422006.94794,TR13E

171,669242.96129,421229.92762,TR13W

172,668592.61748,422922.21362,TR14E

173,669154.27213,421459.37708,TR14W

174,669193.38404,422015.03782,TR15E

175,669223.96130,421230.02747,TR15W

176,668615.65750,422931.08382,TR16E

177,669160.43222,421487.32715,TR16W

178,669169.41406,422018.16762,TR17E

179,669196.97193,421408.14738,TR17W

180,669349.29768,423072.92961,TR18E

181,669403.53421,422048.84893,TR18W

182,668638.68750,422935.95402,TR19E

183,669136.12266,421611.43704,TR19W

184,668220.98093,423860.09134,TR20E

185,668578.64750,422926.29352,TR20W

186,669864.05496,422061.94879,TR21N

187,669487.62430,422039.24890,TR21S

188,669865.99504,422081.73880,TR22N

189,669486.57437,422059.70892,TR22S

190,668653.77756,422953.85415,TR23E

191,668810.42604,422540.07510,TR23W

192,669530.98595,422490.03917,TR24E

193,669539.61449,422069.07890,TR24W

194,668603.69753,422936.15373,TR25E

195,668241.01094,423867.98150,TR25W

196,668670.80757,422958.76429,TR26E

197,668824.42604,422540.99521,TR26W

198,668260.09098,423880.87167,TR27E

199,668624.75755,422948.02391,TR27W

200,668687.83758,422964.66443,TR28E

201,668833.45606,422546.94530,TR28W

202,669512.99592,422490.13918,TR29E

203,669520.03472,422144.16896,TR29W

204,668279.12099,423888.76182,TR30E

205,668636.78756,422952.95401,TR30W

206,668702.86759,422970.58456,TR31E

207,668848.48606,422551.85542,TR31W

208,669497.03592,422498.22918,TR32E

209,669506.06471,422147.24896,TR32W

210,668299.16101,423895.64200,TR33E

211,668663.82759,422962.80423,TR33W

212,668717.91762,422979.49469,TR34E

213,669060.31403,421996.77672,TR34W

214,668324.21103,423905.50221,TR35E

215,668685.87760,422971.67442,TR35W

216,668745.94762,422986.34492,TR36E

217,669145.32340,421823.33728,TR36W

218,668337.22103,423908.43231,TR37E

219,668697.89762,422975.61453,TR37W

220,669330.89111,424065.83027,TR38E

221,669374.72799,423149.77966,TR38W

222,668354.25105,423914.33245,TR39E

223,668709.91762,422980.54462,TR39W

224,668760.96764,422991.24504,TR40E

225,669097.35405,422005.57703,TR40W

226,668369.29107,423921.25259,TR41E

227,668726.95764,422987.43476,TR41W

228,668739.49796,423082.34494,TR42E

229,669109.37405,422008.50712,TR42W

230,669327.41142,424157.82034,TR43N

231,668421.95084,423862.96297,TR43S

232,669187.20824,423227.80868,TR44N

233,668699.67809,423114.57464,TR44S

234,668752.50797,423087.27505,TR45E

235,669124.39406,422012.41725,TR45W

236,669333.32137,424141.79032,TR46N

237,668421.87078,423848.97295,TR46S

238,668768.53798,423092.18519,TR47E

239,669141.40406,422016.32739,TR47W

240,669338.22132,424124.77031,TR48N

241,668427.79073,423833.94299,TR48S

242,668782.56799,423097.10530,TR49E

243,669157.42407,422020.23753,TR49W

244,669332.10123,424101.81031,TR50N

245,668432.70067,423818.91301,TR50S

246,668797.58800,423102.02542,TR51E

247,669175.44408,422025.13768,TR51W

248,669303.96111,424077.97026,TR52N

249,668439.60062,423802.88306,TR52S

250,668813.61801,423107.93556,TR53E

251,669191.42406,422021.04781,TR53W

252,669308.88106,424063.95029,TR54N

253,668441.52056,423787.87307,TR54S

254,668829.62802,423111.84569,TR55E

255,669209.37403,422012.94794,TR55W

256,669311.80101,424048.93027,TR56N

257,668445.44052,423774.85309,TR56S

258,669314.74099,424038.92027,TR57N

259,668451.38047,423762.82312,TR57S

260,669255.41403,422021.68832,TR58E

261,669311.23081,421102.56808,TR58W

262,669632.47260,421491.54852,PIT1NW

263,669670.04414,421913.71876,PIT1NE

264,669603.69407,421919.74880,PIT1SE

265,669582.22252,421489.88853,PIT1SW

266,669579.42097,421049.92826,PIT2NW

267,669689.24417,421913.67876,PIT2N1

268,669694.94441,421978.24880,PIT2NE

269,669467.10413,421998.41888,PIT2SE

270,669524.80091,421054.63827,PIT2SW

271,669834.24619,422422.56901,PIT3NW

272,669836.85655,422525.61907,PIT3NE

273,669456.49656,422700.99933,PIT3SE

274,669462.73615,422580.01925,PIT3SW

275,669387.78433,422092.91896,PIT4NW

276,669341.28766,423068.97963,PIT4NE

277,669226.94745,423005.62883,PIT4SE

278,669276.86431,422103.54856,PIT4SW

279,669690.59823,423068.49946,PIT5NW

280,669804.11900,423234.33950,PIT5N1

281,669792.42918,423290.38954,PIT5NE

282,669415.36923,423484.96985,PIT5SE

283,669429.03822,423188.62965,PIT5S1

284,669457.47782,423061.81956,PIT5SW

285,669339.30767,423071.98963,PIT6NW

286,669318.76916,423510.00992,PIT6NE

287,669197.67914,423489.69896,PIT6SE

288,669225.95746,423007.63883,PIT6SW

289,669780.69264,424284.90011,PIT7

290,669781.79012,423564.12970,PIT8NW

291,669778.25040,423645.06975,PIT8NE

292,669404.86966,423612.29994,PIT8SE

293,669412.19937,423525.87988,PIT8SW

294,669763.80227,424187.07006,PIT9NW

295,669770.00273,424315.57013,PIT9NE

296,669509.16189,424204.86024,PIT9E1

297,669502.92199,424234.74028,PIT9E2

298,669405.68162,424177.16030,PIT9SE

299,669396.14123,424069.16024,PIT9SW

300,669077.20733,422951.02757,ACIDPITNW

301,669065.61804,423152.89763,ACIDPITNE

302,668957.54803,423132.93674,ACIDPITSE

303,668968.04737,422945.49669,ACIDPITSW

304,669250.87432,422103.68835,PIT10NW

305,669193.06815,423202.77870,PIT10NE

306,669096.95812,423180.32791,PIT10SE

307,669119.42531,422373.37748,PIT10S1

308,669184.94438,422114.06781,PIT10SW

309,669194.32831,423249.75875,PIT11NW

310,669190.70916,423493.72891,PIT11NE

311,669092.74923,423498.28812,PIT11SE

312,669099.22829,423228.29797,PIT11SW

313,669081.17826,423217.40781,PIT12NW

314,669066.46924,423498.43791,PIT12NE

315,669002.15923,423487.54738,PIT12E1

316,668964.33921,423473.87706,PIT12SE

317,668977.02821,423186.99695,PIT12SW

318,669082.00712,422889.13757,PIT13NE

319,668968.67733,422930.81669,PIT13SE

320,669111.80589,422537.89754,PIT13W

321,669326.46145,424166.82034,PIT14NW

322,669318.62153,424194.87037,PIT14NE

323,668399.28105,423922.08283,PIT14SE

324,668423.99086,423870.95298,PIT14SW

325,669325.50059,423917.65019,PIT15NW

326,669327.37094,424019.69024,PIT15NE

327,668459.76039,423738.36318,PIT15SE

328,668479.89014,423671.45329,PIT15SW

329,669336.23996,423732.52006,PIT16NW

330,669325.49058,423916.66019,PIT16NE

331,668885.48034,423789.54666,PIT16SE

332,668898.68021,423755.40674,PIT16SW

333,669288.88035,423855.09997,PIT16W1

334,669347.10933,423545.98993,PIT17NW

335,669336.23996,423732.52006,PIT17N1

336,669288.88035,423855.09997,PIT17NE

337,669071.72027,423799.61817,PIT17SE

338,669163.11924,423514.80869,PIT17SW

339,669163.11924,423514.80869,PIT18NW

340,669071.72027,423799.61817,PIT18NE

341,668898.68021,423755.40674,PIT18SE

342,669002.15923,423487.54738,PIT18SW

343,669002.15923,423487.54738,PIT19NW

344,668885.48034,423789.54666,PIT19NE

345,668692.80024,423733.44506,PIT19SE

346,668814.07909,423419.54580,PIT19SW

347,668814.07909,423419.54580,PIT20NW

348,668692.80024,423733.44506,PIT20NE

349,668500.12014,423677.34345,PIT20SE

350,668625.98895,423351.56423,PIT20SW

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Appendix D

Drawings

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Appendix D

Drawings

This appendix provides the following drawings that support the project measurement and control engineering studies of this EDF:

- Drawing 416511, Sheet 1, Radioactive Waste Management Complex Diagram
- Drawing 416511, Sheet 2, Pit and Trench Coordinates
- Figure 1, SDA Site Plan, Soil Vault and Trench Plan
- Figure 2, Enlarged Plan for Cold Test Pit – North, with Coordinate Table
- Figure 3, Enlarged Plan for Area 22 SVR-12, and Area 15 SVR-14
- Figure 4, Simplified P&ID for Grout Ingredient Storage Subsystem
- Figure 5, Simplified P&ID for the Grout Ingredient Storage Subsystem and Grout Mixing Subsystem
- Figure 6: Simplified P&ID for the Grout Low-Pressure, High-Pressure Subsystem and Injection Positioning subsystems
- Figure 7: Block Diagram for the Digital Video Recorder & SCADA System & Wireless Block Diagram

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2	1	SHEETS	REV STATUS OF SHEETS
31	31	REV	

REVISIONS

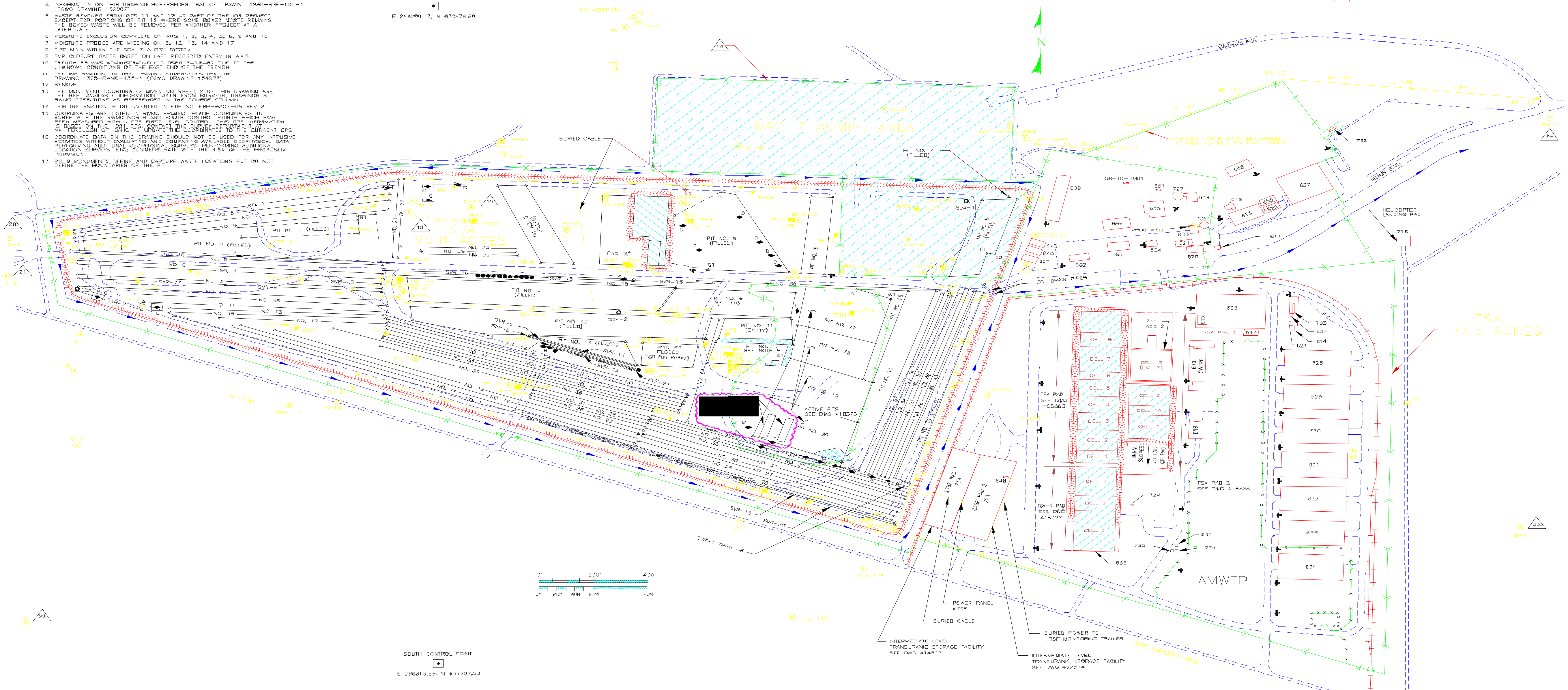
REV	DESCRIPTION	DATE	APPROVED
29	ADDED DRAWING AFFECTED BY STATEMENT FOR ECF-2365, AS-BUILT AS OF 3/4/02, SEE DAR-98397	2/19/03	
30	REMOVED DRAWING AFFECTED BY STATEMENT AND INCORPORATED INFORMATION FROM INTERIM DRAWING 623304 REV 1 PER ECF-2365, AS-BUILT AS OF 4/7/03, SEE DAR-84453	6/23/03	
31	INCORPORATED ADDITIONAL RH-LLWD VAULTS LOCATED IN PIT NO. 20, AS-BUILT AS OF 7/23/03, SEE DAR-106544	12/4/03	

NOTES:

1. TRENCH WASTE LOCATIONS ARE DETERMINED BY MEASUREMENTS MADE FROM EAST TO WEST AND NORTH TO SOUTH OF MONUMENTS
2. PIT BURIAL LOCATIONS ARE DETERMINED BY REFERENCE TO NORTHEAST CORNER MONUMENTS
3. FEATURES SUCH AS FENCES, BUILDINGS, MONITORING WELLS, DIKES, DITCHES, ROADS & POWER LINES ARE LOCATED PER 1989 & 1990 SURVEYS. MONUMENTS FOR PITS AND TRENCHES ARE LOCATED PER SOURCE INFORMATION ON SHEET 2 OF THIS DRAWING. MONITORING STATIONS & UNNUMBERED PITS ARE LOCATED ACCORDING TO INFORMATION PER 1989 SURVEY AND EG&G DRAWING 416511 REV M
4. INFORMATION ON THIS DRAWING SUPERSEDES THAT OF DRAWING 1230-BGF-101-1 (EG&G DRAWING 152907)
5. WASTE REMOVED FROM PITS 11 AND 12 AS PART OF THE IDR PROJECT EXCEPT FOR PORTIONS OF PIT 12 WHERE SOME BOXED WASTE REMAINS. THE BOXED WASTE WILL BE REMOVED PER ANOTHER PROJECT AT A LATER DATE
6. MOISTURE EXCLUSION COMPLETE ON PITS 1, 2, 3, 4, 5, 6, 9 AND 10
7. MOISTURE PROBES ARE MISSING ON 8, 12, 13, 14 AND 17
8. FIRE MAIN WITHIN THE SDA IS A DRY SYSTEM
9. SVR CLOSURE DATES BASED ON LAST RECORDED ENTRY IN WMIS
10. TRENCH 55 WAS ADMINISTRATIVELY CLOSED 3-12-82 DUE TO THE UNKNOWN CONDITIONS OF THE EAST END OF THE TRENCH
11. THE INFORMATION ON THIS DRAWING SUPERSEDES THAT OF DRAWING 1375-RWMC-135-1 (EG&G DRAWING 154978)
12. REMOVED
13. THE MONUMENT COORDINATES GIVEN ON SHEET 2 OF THIS DRAWING ARE THE BEST AVAILABLE INFORMATION TAKEN FROM SURVEYS, DRAWINGS & RWMC OPERATIONS AS REFERENCED IN THE SOURCE COLUMN
14. THIS INFORMATION IS DOCUMENTED IN EDF NO. ERP-WAG7-05 REV 2
15. COORDINATES ARE LISTED IN RWMC PROJECT PLANE COORDINATES TO AGREE WITH THE RWMC NORTH AND SOUTH CONTROL POINTS WHICH HAVE BEEN MEASURED WITH A GPS FIRST LEVEL CONTROL. THIS GPS INFORMATION IS BASED ON THE 1991 GPS. CONTACT THE SURVEY DEPARTMENT AT MK-FERGUSON OF IDAHO TO UPDATE THE COORDINATES TO THE CURRENT GPS
16. COORDINATE DATA ON THIS DRAWING SHOULD NOT BE USED FOR ANY INTRUSIVE ACTIVITIES WITHOUT EVALUATING AND COMPARING AVAILABLE GEOPHYSICAL DATA, PERFORMING ADDITIONAL GEOPHYSICAL SURVEYS, PERFORMING ADDITIONAL LOCATION SURVEYS, ETC.; COMMENSURATE WITH THE RISK OF THE PROPOSED INTRUSION
17. PIT 9 MONUMENTS DEFINE AND CAPTURE WASTE LOCATIONS BUT DO NOT DEFINE THE BOUNDARIES OF THE PIT

18. CONFIGURATION MANAGEMENT WILL NOT BE MAINTAINED WITHIN THE HATCHED BOUNDARY AND IS THE RESPONSIBILITY OF THE OPERATING CONTRACTOR OPERATING UNDER SUBCONTRACT C91-133136 UNTIL THE COMPLETION AND TURNOVER OF THE PIT 9 PROJECT
19. WELLS W-18 & W-20 ARE ABANDONED IN PLACE AND COVERED WITH OVERBURDEN
20. MONITORING WELL D-4 NOT SHOWN TO SCALE. LOCATION SHOWN IS 150' EAST OF ACTUAL LOCATION. TRUE COORDINATES ARE N 669761.956, E 264604.598. REFERENCE NOTE 15
21. MONITORING WELL O-5 NOT SHOWN TO SCALE. LOCATION SHOWN IS 750' EAST OF ACTUAL LOCATION. TRUE COORDINATES ARE N 669578.043, E 263992.196. REFERENCE NOTE 15
22. MONITORING WELL O-7 NOT SHOWN TO SCALE. LOCATION SHOWN IS 250' EAST OF ACTUAL LOCATION. TRUE COORDINATES ARE N 667916.880, E 264563.986. REFERENCE NOTE 15
23. MONITORING WELL O-9 NOT SHOWN TO SCALE. LOCATION SHOWN IS 1000' WEST OF ACTUAL LOCATION. TRUE COORDINATES ARE N 668361.816, E 271257.532. REFERENCE NOTE 15
24. MONITORING WELL O-10 NOT SHOWN TO SCALE. LOCATION SHOWN IS 900' WEST OF ACTUAL LOCATION. TRUE COORDINATES ARE N 670340.842, E 271265.845. REFERENCE NOTE 15

NORTH CONTROL POINT
E 266299.17, N 670878.69



SOUTH CONTROL POINT
E 266318.99, N 667707.53

LEGEND

APPROXIMATE LOCATION	DIKE OR BERM
FENCE	POWER LINE
ROAD	DRAINAGE DITCH SHOWING FLOW PATH
FILLED TRENCH	PIT RAD WASTE < 10 N C /GRAM
UNFILLED PORTION OF SOIL VAULT ROW (AS OF 18 JAN 2000)	PIT RAD WASTE BETA GAMMA
DISPOSAL BOUNDARY MONUMENT	PIT RAD WASTE > 10 NC /GRAM
MONITORING STATION	FIRE HYDRANT
MONITORING WELL U.N.D.	SUMP
NEUTRON MOISTURE PROBE HOLE	SHALLOW SOIL <12"
TENSIOMETER PROBE HOLE	MASTODON/CAMEL BONE ENCOUNTERED DURING EXCAVATION
SDA CONTROL MONUMENT	UNRECORDED WASTE
RAILROAD	

INFORMATION ON UNRECORDED WASTE [REFERENCE FOR "A" THRU "K" IS 416511-M]

A. HIT WASTE AT 3' BELOW SURFACE DURING DRILLING OPERATIONS OF SVR-16 37' WEST OF EAST MONUMENT 3-14-85
B. HIT WASTE AT APPROX 6' BELOW SURFACE DURING DRILLING OPERATIONS OF SVR-11 331', 335' & 343' WEST OF EAST MONUMENT 2-20-84
C. HIT WASTE AT APPROX 5' BELOW SURFACE DURING TEST WELL DRILLING
C & D. IDENTIFIED IN REPORT WMP 77-3 BY D.H. CARD, MARCH 1977
E. ENCOUNTERED SCRAP MATERIAL DURING EXCAVATION OF WHAT IS NOW PIT 17 — NO CONTAMINATION OR RADIATION DETECTED
F. "HOT" SPOT UNCOVERED DURING EXCAVATION OF WHAT IS NOW PIT 20
G. IDENTIFIED AS SHALLOW FILLED PITS, NO SPECIFIC LOCATION GIVEN
H. ENCOUNTERED WASTE DURING DRILLING OF SVR-12, CLOSED VAULT ROW 7-83
J. ENCOUNTERED WASTE DURING EWR PROJECT
K. ENCOUNTERED WASTE DURING DRILLING OF SVR-12 IN 1982, REFER TO EDF RWMC-112
L. ENCOUNTERED WOODEN WASTE BOX AT 9' BELOW SURFACE ON 9-23-92 DURING EXCAVATION FOR INSTALLATION OF LOW LEVEL REMOTE HANDLED STORAGE VAULTS, REFER TO NCR-RWMC-091
M. ENCOUNTERED CONTAMINATED SOIL ON 4-29-93 DURING EXCAVATION FOR INSTALLATION OF CONCRETE VAULT PAD, REFER TO O.R. RWMC-93-9

THIS DRAWING IS QUALITY LEVEL 2

QTY. REQD.		QUAL. LEVEL	PART OR IDENTIFYING NO.	DESCRIPTION/MATERIAL/SPECIFICATION	ITEM/FIND

PARTS LIST

DIMENSIONING AND SYMBOLOGY ARE AMERICAN NATIONAL STANDARD UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS 125
DIMENSIONS AND TOLERANCES ARE IN INCHES
TOLERANCES: .X = ± .1
DECIMALS: .XX = ± .03
.XXX = ± .010
FRACTIONS ± 1/8
ANGULAR ± 2°
DO NOT SCALE DRAWING

NEXT ASSY/REF DWG: FINAL
PROG. MGR. J.H. NELSON DATE 11/16/81
QUALITY R.W.P.
DES. MGR. R.W.P.
REQUESTER R.W. PASSMORE DATE 4/29/82
DESIGN R.W.P.
CHECKED R.W. PASSMORE DATE 4-29-82
DRAWN B.L. SCOTT DATE 8-8-91
RELEASE BJG DATE 5-4-82

EG&G Idaho, Inc.
RWMC
RADIOACTIVE WASTE MANAGEMENT COMPLEX DIAGRAM

SIZE E | INDEX CODE NUMBER: AREA 098, TYPE 0135, CL 38, ORIG 220 | DRAWING NO. 416511 | REV 31
SCALE 1"=200'
SPEC CODE

RW-1066 SHEET 1 OF 2 PROJ. NO. 015575

ADDCS NO. 30792

File: 416511-31.dwg ID. KSK
Path: P:\RWMC\d-vaults\As-Built
Drawn in Model Space
Date: 12/04/03 - 08:56 A.M.

*SVR	DATE OPENED	DATE CLOSED	MONUMENTS IDENTITY	MONUMENTS COORDINATES	MONUMENTS SOURCE
1	3-3-77	9-7-77	EAST WEST	E 268035.88 N 668571.22 E 268006.81 N 668584.06	EDF, SEE NOTE 14
2	3-16-77	10-28-77	EAST WEST	E 268034.89 N 668569.22 E 268002.82 N 668582.04	EDF, SEE NOTE 14
3	3-14-77	10-27-77	EAST WEST	E 268032.92 N 668565.21 E 268003.84 N 668578.04	EDF, SEE NOTE 14
4	3-17-77	11-1-77	EAST WEST	E 268031.94 N 668561.20 E 267999.87 N 668574.02	EDF, SEE NOTE 14
5	3-15-77	9-2-77	EAST WEST	E 268030.95 N 668559.20 E 268000.88 N 668571.03	EDF, SEE NOTE 14
6	3-25-78	2-27-81	EAST WEST	E 267039.26 N 669141.37 E 266646.24 N 669285.26	1981
7	5-8-78	1-23-79	EAST WEST	E 265235.11 N 669412.50 E 264997.59 N 669505.16	EDF, SEE NOTE 14
8	2-12-78	9-8-81	EAST WEST	E 267038.20 N 669137.77 E 266646.56 N 669281.23	1981
9	2-6-79	7-15-81	EAST WEST	E 266110.59 N 669500.97 E 265543.24 N 669533.25	1991
10	6-9-81	11-3-82	EAST WEST	E 266108.41 N 669539.41 E 265834.32 N 669555.87	EDF, SEE NOTE 14
11	8-7-81	12-12-84	EAST WEST	E 267036.72 N 669131.62 E 266722.07 N 669246.85	EDF, SEE NOTE 14
12	5-5-82	7-27-83	EAST WEST	E 267989.86 N 668574.96 E 267186.13 N 668880.45	EDF, SEE NOTE 14
13	4-4-83	12-21-84	EAST WEST	E 267316.43 N 669540.20 E 267025.34 N 669554.56	EDF, SEE NOTE 14
14	10-16-84	5-8-89	EAST WEST	E 267035.75 N 669128.16 E 266726.44 N 669241.55	1989
15	10-16-84	3-17-87	EAST WEST	E 267025.35 N 669553.56 E 266266.44 N 669589.29	EDF, SEE NOTE 14
16	10-16-84	1-22-90	EAST WEST	E 267028.39 N 669560.53 E 266117.04 N 669604.62	1986
17	4-24-87	5-15-93	EAST WEST	E 265542.43 N 669534.23 E 265005.95 N 669566.01	EDF, SEE NOTE 14
18	2-12-87	10-4-93	EAST WEST	E 267035.77 N 669122.61 E 266720.12 N 669237.84	EDF, SEE NOTE 14
19	1-22-90	8-28-91	EAST WEST	E 267979.92 N 668385.91 E 266646.83 N 668894.13	EDF, SEE NOTE 14
20	8-29-91		EAST WEST	E 267978.97 N 668377.90 E 266641.90 N 668887.61	EDF, SEE NOTE 14
21	11-2-93		EAST WEST	E 267034.23 N 669118.38 E 266718.57 N 669233.61	OPERATIONS

* SEE NOTE 9, SHEET 1

PAD	DATE OPENED	DATE CLOSED	MONUMENTS IDENTITY	MONUMENTS COORDINATES	MONUMENTS SOURCE
A	9-26-72	11-17-78	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 266914.85 N 669967.51 E 267154.71 N 669959.09 E 267142.97 N 669624.30 E 266903.11 N 669632.71	416511-M

TRENCH NO.		DATE OPENED	DATE CLOSED	MONUMENTS IDENTITY	MONUMENTS COORDINATES	MONUMENTS SOURCE
1	TRENCH	7-8-52	10-1-54	EAST WEST	E 266118.16 N 670004.74 E 264988.15 N 669798.72	1981
2	** C. L.	10-1-54	12-21-54	EAST WEST	E 266109.46 N 669459.61 E 265005.89 N 669527.08	1981
3	56' TO 57'	12-22-54	4-22-55	EAST WEST	E 266111.68 N 669516.43 E 265002.46 N 669582.90	1981
4	52' TO 47'	4-22-55	11-21-55	EAST WEST	E 266113.58 N 669562.92 E 264998.97 N 669635.26	1981
5	34' TO 20'	11-4-55	3-29-56	EAST WEST	E 266139.11 N 669974.55 E 264989.28 N 669782.01	1981
6	17' TO 25'	3-22-56	9-4-56	EAST WEST	E 266114.55 N 669587.42 E 264997.74 N 669652.54	1981
7	32' TO 19'	8-14-56	12-20-56	EAST WEST	E 266137.16 N 669941.99 E 264990.57 N 669762.20	1981
8	16' TO 25'	12-13-56	5-7-57	EAST WEST	E 266112.91 N 669628.43 E 264995.56 N 669688.16	EDF, SEE NOTE 14
9	47' TO 19'	1-17-57	9-6-57	EAST WEST	E 266134.02 N 669896.38 E 264991.86 N 669743.24	1981
10	18' TO 30'	7-19-57	2-7-58	EAST WEST	E 266132.85 N 669639.55 E 264978.49 N 669701.06	EDF, SEE NOTE 14
11	62' TO 55'	2-11-58	7-25-58	EAST WEST	E 266130.22 N 669403.64 E 265243.21 N 669451.98	1981
12	NA	1-3-58	1-16-59	EAST WEST	E 267027.82 N 668757.56 E 265354.28 N 669382.17	EDF, SEE NOTE 14
13	27' TO 17'	1-9-58	4-24-59	EAST WEST	E 266116.27 N 669387.45 E 265339.07 N 669421.08	EDF, SEE NOTE 14
14	27' TO 12'	4-16-59	7-30-59	EAST WEST	E 267031.75 N 668770.58 E 265568.57 N 669332.37	EDF, SEE NOTE 14
15	17'	7-31-59	10-16-59	EAST WEST	E 266124.36 N 669371.49 E 265339.17 N 669402.08	EDF, SEE NOTE 14
16	16' TO 24'	10-17-59	4-12-60	EAST WEST	E 267040.62 N 668793.63 E 265596.53 N 669338.53	EDF, SEE NOTE 14
17	17' TO 23'	11-1-59	7-1-60	EAST WEST	E 266127.49 N 669347.51 E 265517.33 N 669375.08	EDF, SEE NOTE 14
18	NA	5-10-60	7-20-60	EAST WEST	E 267182.50 N 669527.44 E 266158.18 N 669581.69	EDF, SEE NOTE 14
19	20' TO 24'	7-5-60	11-29-60	EAST WEST	E 267045.49 N 668816.66 E 265720.67 N 669314.22	EDF, SEE NOTE 14
20	NA	12-1-60	6-30-61	EAST WEST	E 267969.85 N 668398.85 E 267035.83 N 668756.61	EDF, SEE NOTE 14
21	NA	12-13-60	1-10-61	NORTH SOUTH	E 266171.28 N 670042.31 E 266148.58 N 669665.80	1981
22	20' TO 21'	2-1-61	4-25-61	NORTH SOUTH	E 266191.08 N 670044.26 E 266169.04 N 669664.75	1981
23	18' TO 21'	6-20-61	9-15-61	EAST WEST	E 267063.40 N 668831.76 E 266649.52 N 668988.44	EDF, SEE NOTE 14
24	NA	10-1-61	7-31-62	EAST WEST	E 266599.47 N 669709.17 E 266178.41 N 669717.80	EDF, SEE NOTE 14
25	27' TO 22'	8-1-61	7-27-62	EAST WEST	E 267045.69 N 668781.66 E 267977.74 N 668418.89	EDF, SEE NOTE 14
26	15' TO 17'	4-13-62	8-17-62	EAST WEST	E 267068.31 N 668848.79 E 266650.44 N 669002.44	EDF, SEE NOTE 14
27	18' TO 22'	8-20-62	1-4-63	EAST WEST	E 267990.63 N 668437.97 E 267057.57 N 668802.73	EDF, SEE NOTE 14
28	11' TO 18'	12-26-62	3-12-63	EAST WEST	E 267074.21 N 668865.82 E 266656.39 N 669011.48	EDF, SEE NOTE 14
29	18'	11-19-62	3-20-63	EAST WEST	E 266599.57 N 669691.17 E 266253.52 N 669698.22	EDF, SEE NOTE 14
30	13' TO 21'	3-2-63	9-12-63	EAST WEST	E 267998.52 N 668457.01 E 267062.50 N 668814.76	EDF, SEE NOTE 14
31	16'	3-25-63	11-22-63	EAST WEST	E 267080.13 N 668880.86 E 266661.30 N 669026.51	EDF, SEE NOTE 14
32	16' TO 13'	4-1-63	11-18-63	EAST WEST	E 266607.66 N 669675.21 E 266256.60 N 669684.24	EDF, SEE NOTE 14
33	29' TO 21'	10-11-63	8-11-64	EAST WEST	E 268005.41 N 668477.05 E 267072.35 N 668841.81	EDF, SEE NOTE 14
34	29' TO 24'	3-18-64	8-27-64	EAST WEST	E 267089.04 N 668895.91 E 266106.10 N 669238.39	EDF, SEE NOTE 14
35	24' TO 28'	8-28-64	1-19-65	EAST WEST	E 268015.27 N 668502.11 E 267081.22 N 668863.86	EDF, SEE NOTE 14
36	16' TO 15'	12-1-64	7-24-65	EAST WEST	E 267095.89 N 668923.95 E 265932.62 N 669323.42	EDF, SEE NOTE 14
37	NA	12-24-64	7-1-65	EAST WEST	E 268018.20 N 668515.12 E 267085.16 N 668875.89	EDF, SEE NOTE 14
38	NA	5-15-65	9-16-65	EAST WEST	E 268175.62 N 669509.02 E 267259.36 N 669552.87	EDF, SEE NOTE 14
39	13' TO 18'	7-20-65	11-5-65	EAST WEST	E 268024.10 N 668532.16 E 267090.09 N 668887.91	EDF, SEE NOTE 14
40	14' TO 13'	10-7-65	1-13-66	EAST WEST	E 267100.80 N 668938.97 E 266114.90 N 669275.44	EDF, SEE NOTE 14
41	18' TO 16'	1-4-66	10-4-66	EAST WEST	E 268031.02 N 668547.20 E 267096.99 N 668904.95	EDF, SEE NOTE 14
42	13' TO 19'	5-9-66	1-17-67	EAST WEST	E 267191.92 N 668917.49 E 266117.83 N 669287.46	EDF, SEE NOTE 14
43	TO	10-20-66	6-1-67	NORTH SOUTH	E 268267.64 N 669505.54 E 267972.72 N 668599.87	EDF, SEE NOTE 14
44	NA	1-13-67	3-24-67	NORTH SOUTH	E 267337.41 N 669365.31 E 267224.15 N 668877.67	EDF, SEE NOTE 14
45	16' TO 14'	2-28-67	9-27-67	EAST WEST	E 267196.85 N 668930.51 E 266121.74 N 669302.48	EDF, SEE NOTE 14
46	17' TO 19'	9-25-67	3-14-68	NORTH SOUTH	E 268251.60 N 669511.45 E 267958.72 N 668599.79	EDF, SEE NOTE 14
47	17' TO 16'	2-28-68	8-5-68	EAST WEST	E 267201.76 N 668946.54 E 266125.65 N 669319.50	EDF, SEE NOTE 14
48	16' TO 18'	8-8-68	5-2-69	NORTH SOUTH	E 268234.58 N 669516.35 E 267943.69 N 668605.71	EDF, SEE NOTE 14
49	16' TO 14'	11-18-68	6-30-69	EAST WEST	E 267206.68 N 668960.57 E 266129.56 N 669335.52	EDF, SEE NOTE 14
50	16' TO 21'	7-1-69	11-1-69	NORTH SOUTH	E 268211.61 N 669510.23 E 267928.66 N 668610.62	EDF, SEE NOTE 14
51	18' TO 17'	10-30-69	4-8-70	EAST WEST	E 267211.60 N 668975.60 E 266134.46 N 669353.55	EDF, SEE NOTE 14
52	18' TO 14'	3-4-70	7-4-70	NORTH SOUTH	E 268187.77 N 669482.09 E 267912.62 N 668617.53	EDF, SEE NOTE 14
53	15' TO 17'	7-1-70	10-12-70	EAST WEST	E 267217.51 N 668991.63 E 266130.37 N 669369.53	EDF, SEE NOTE 14
54	15'	9-23-70	5-4-71	NORTH SOUTH	E 268173.74 N 669487.01 E 267897.61 N 668619.45	EDF, SEE NOTE 14
SEE NOTE 10, SHEET 1 → 55	16'	4-7-71	3-12-82	EAST WEST	E 267221.42 N 669007.65 E 266122.27 N 669387.48	EDF, SEE NOTE 14
56	14'	12-29-71	2-1-73	NORTH SOUTH	E 268158.72 N 669489.93 E 267884.59 N 668623.37	EDF, SEE NOTE 14
57	11'	12-28-72	6-11-74	NORTH SOUTH	E 268148.71 N 669492.87 E 267872.55 N 668629.31	EDF, SEE NOTE 14
58	NA	2-20-74	8-17-81	EAST WEST	E 266131.01 N 669433.53 E 265211.68 N 669489.37	EDF, SEE NOTE 14

** DISTANCE FROM PREVIOUS TRENCH PER 416511-M

PIT NO.	DATE OPENED	DATE CLOSED	MONUMENTS IDENTITY	MONUMENTS COORDINATES	MONUMENTS SOURCE
1	11-1-57	10-1-59	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 265600.75 N 669810.68 E 266023.02 N 669848.26 E 266029.05 N 669781.89 E 265599.09 N 669760.42	416511-M 1981 416511-M 416511-M
2	10-1-59	7-1-63	NORTHWEST N1 NORTHEAST SOUTHEAST SOUTHWEST	E 265159.03 N 669757.62 E 266022.98 N 669867.46 E 266087.56 N 669873.17 E 266107.74 N 669645.27 E 265163.74 N 669702.99	1989 416511-M 416511-M 1989 1989
3	12-15-61	1-3-63	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 266531.98 N 670012.50 E 266635.06 N 670015.11 E 266810.48 N 669634.66 E 266689.47 N 669640.90	1989 1981 1989 1989
4	1-3-63	9-26-67	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 266202.26 N 669565.93 E 267178.54 N 669519.42 E 267115.18 N 669405.06 E 266212.89 N 669454.99	EDF, SEE NOTE 14
5	6-18-63	12-22-66	NORTHWEST N1 NORTHEAST SOUTHEAST S1 SOUTHWEST	E 267178.06 N 669868.81 E 267343.94 N 669982.36 E 267400.01 N 669970.67 E 267594.63 N 669593.52 E 267298.22 N 669607.19 E 267171.38 N 669635.64	EDF, SEE NOTE 14
6	5-18-67	10-22-68	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267181.55 N 669517.44 E 267619.68 N 669496.90 E 267599.36 N 669375.78 E 267117.19 N 669404.07	EDF, SEE NOTE 14
7	9-19-66	10-5-68	N/A	E 268394.75 N 669958.93	1981
8	3-6-67	11-69	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267673.81 N 669960.03 E 267754.77 N 669956.49 E 267721.99 N 669583.02 E 267635.55 N 669590.35	1981
9	11-8-67	6-9-69	NORTHWEST NORTHEAST E1 E2 SOUTHEAST SOUTHWEST	E 268296.89 N 669942.03 E 268425.42 N 669948.23 E 268314.69 N 669687.33 E 268344.57 N 669681.09 E 268286.98 N 669583.83 E 268178.96 N 669574.29	NCR 3029 R1 SEE NOTE 17
ACID PIT	1-1-54	1-1-61	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267060.57 N 669255.28 E 267262.48 N 669243.69 E 267242.52 N 669135.60 E 267055.04 N 669146.10	1981
10	8-7-68	7-8-71	NORTHWEST NORTHEAST SOUTHEAST S1 SOUTHWEST	E 266213.03 N 669428.99 E 267312.38 N 669371.17 E 267289.92 N 669275.04 E 266482.78 N 669297.51 E 266223.41 N 669363.05	EDF, SEE NOTE 14
11	4-14-70	10-16-70	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267359.37 N 669372.43 E 267603.39 N 669368.81 E 267607.95 N 669270.83 E 267337.90 N 669277.31	EDF, SEE NOTE 14
12	7-2-70	9-12-72	NORTHWEST NORTHEAST E1 SOUTHEAST SOUTHWEST	E 267327.01 N 669259.25 E 267608.10 N 669244.54 E 267597.21 N 669180.22 E 267583.54 N 669142.39 E 267296.59 N 669155.08	EDF, SEE NOTE 14
13	7-20-71	7-29-74	NORTHEAST SOUTHEAST WEST	E 266998.66 N 669260.08 E 267040.35 N 669146.73 E 266647.34 N 669289.89	1981
14	7-1-74	3-31-76	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 268276.64 N 669504.59 E 268304.69 N 669496.75 E 268031.85 N 668577.20 E 267980.71 N 668601.91	EDF, SEE NOTE 14
15	6-25-75	7-3-84	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 268027.41 N 669503.63 E 268129.47 N 669505.50 E 267848.09 N 668637.69 E 267781.16 N 668657.82	1986 1989 1989 1986
16	5-22-78	10-25-84	NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST W1	E 267842.24 N 669514.37 E 268026.42 N 669503.62 E 267899.28 N 669063.51 E 267865.13 N 669076.71 E 267964.85 N 669467.00	1986 1986 418373-B 418373-B 418373-B
17	5-5-84		NORTHWEST N1 NORTHEAST SOUTHEAST SOUTHWEST	E 267655.66 N 669525.25 E 267842.24 N 669514.37 E 267964.85 N 669467.00 E 267909.35 N 669249.79 E 267624.48 N 669341.21	418373-B
18	3-1-88		NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267624.48 N 669341.21 E 267909.35 N 669249.79 E 267865.13 N 669076.71 E 267597.21 N 669180.22	418373-B
19			NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267597.21 N 669180.22 E 267899.28 N 669063.51 E 267843.17 N 668870.78 E 267529.20 N 668992.09	418373-B
20			NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267529.20 N 668992.09 E 267843.17 N 668870.78 E 267787.05 N 668678.06 E 267461.20 N 668803.96	418373-B

DISPOSAL VAULTS

VAULT TYPE	DATE OPENED	DATE CLOSED	MONUMENTS IDENTITY	MONUMENTS COORDINATES	MONUMENTS SOURCE
RH-LLW	8-2-94		NORTHWEST NORTHEAST SOUTHEAST SOUTHWEST	E 267518.15 N 668912.77 E 267608.75 N 668886.04 E 267576.06 N 668776.01 E 267485.31 N 668802.89	177322 177721 518784

MONITORING STATIONS

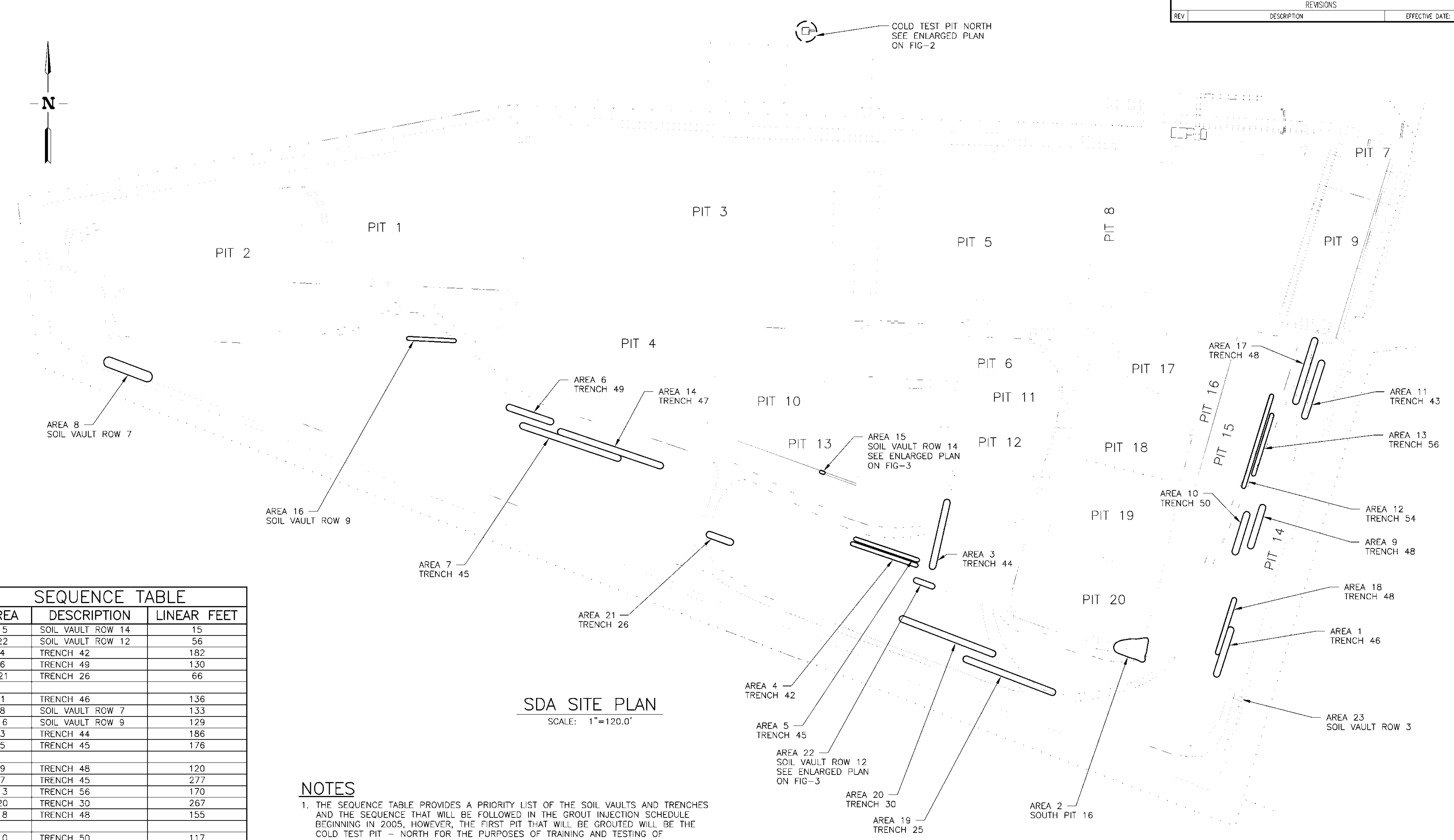
STATION	DEPTH TO BASALT
1	14'-5"
2	13'-0"
3	10'-6"
4	10'-0"
5	9'-0"
6	15'-5"
7	10'-0"
8	REMOVED
9	REMOVED
10	6'-5"
11	20'-5"
12	REMOVED
13	REMOVED
14	REMOVED
15	REMOVED
16	REMOVED
17	REMOVED
18	BENT
19	15'-0"
20	4'-0"
21	REMOVED
22	8'-0"
23	6'-0"
24	REMOVED
25	10'-0"
26	11'-5"
27	12'-5"

TSA #1	DATE OPENED	DATE CLOSED
CELL 1	11-1-70	5-18-71
CELL 2	5-19-71	12-27-71
CELL 3	12-15-71	6-5-72
CELL 4	6-5-72	1-15-73
CELL 5	12-22-72	6-20-73
CELL 6	5-24-73	11-7-73
CELL 7	11-7-73	1-23-75
CELL 8	4-24-74	10-25-75

TSA #2	DATE OPENED	DATE CLOSED
CELL 1	9-75	12-77
CELL 1A	7-80	7-80
CELL 2	12-77	7-80
CELL 3	8-80	7-97

SDA CONTROL MONUMENTS

IDENTITY	COORDINATES
SDA-1	E 268239.24 N 669938.64
SDA-2	E 266973.93 N 669400.01
SDA-3	E 265000.56 N 669514.42



SDA SITE PLAN

SCALE: 1"=120.0'

SEQUENCE TABLE

AREA	DESCRIPTION	LINEAR FEET
15	SOIL VAULT ROW 14	15
22	SOIL VAULT ROW 12	56
4	TRENCH 42	182
6	TRENCH 49	130
21	TRENCH 26	66
1	TRENCH 46	136
8	SOIL VAULT ROW 7	133
16	SOIL VAULT ROW 9	129
3	TRENCH 44	186
5	TRENCH 45	176
9	TRENCH 48	120
7	TRENCH 45	277
13	TRENCH 56	170
20	TRENCH 30	267
18	TRENCH 48	155
10	TRENCH 50	117
17	TRENCH 48	181
11	TRENCH 43	160
2	SOUTH PIT 16	
14	TRENCH 47	289
19	TRENCH 25	256
12	TRENCH 54	235
23	SOIL VAULT ROW 3	

NOTES

1. THE SEQUENCE TABLE PROVIDES A PRIORITY LIST OF THE SOIL VAULTS AND TRENCHES AND THE SEQUENCE THAT WILL BE FOLLOWED IN THE GROUT INJECTION SCHEDULE BEGINNING IN 2005. HOWEVER, THE FIRST PIT THAT WILL BE GROUTED WILL BE THE COLD TEST PIT – NORTH FOR THE PURPOSES OF TRAINING AND TESTING OF EQUIPMENT AND PROCEDURES.
2. REFER TO FIG-2 FOR AN ENLARGED DETAIL OF THE COLD TEST PIT – NORTH.
3. REFER TO FIG-3 FOR AN ENLARGED DETAIL OF SOIL VAULT ROW 14 IN AREA 15.
4. REFER TO FIG-3 FOR AN ENLARGED DETAIL OF SOIL VAULT ROW 12 IN AREA 22.

FOR DRAWING INDEX SEE DRAWING NO.	SUBCONTRACT NO.	INEEL Idaho National Engineering & Environmental Laboratory BECHTEL BWXT IDAHO, LLC
SCALE: 1" = 120.0'	REQUESTER: FRANK WEBBER; DESIGN: P. BUNNELL; DRAWN: R. PENCE	OU 7-13/14 ISG PHASE 2
	PROJECT NO. 23833; SPCL CODE	SDA SITE PLAN, SOIL VAULT & TRENCH PLAN
DESIGN PHASE: CONCEPTUAL	FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.	SIZE D; CAGE CODE 01MF3; INDEX CODE NUMBER AREA 098 TYPE 0100 CL 02 ORIG 090; DWG– ; REV
SAFETY CATEGORY: CG	EFFECTIVE DATE:	SCALE NOTED; SHEET FIG-1

REVISIONS: REV | DESCRIPTION | EFFECTIVE DATE:

File: PIT_TRENCH.dwg Path: P:\RWMC WAG 7 ISG Conceptual Design Report\control dwgs\ Layout Name: SITEPLAN Date: 08/25/04 – 10:16 A.M. ID: BBY

FMT-01-REV 3.4

COORDINATE TABLE

DATUM:
HORIZONTAL:

NO.	NORTHING	EASTING
1	670160.65	266841.89
2	670160.65	266844.78
3	670160.65	266847.67
4	670160.65	266850.55
5	670160.65	266853.44
6	670160.65	266856.33
7	670160.65	266859.21
8	670159.82	266840.45
9	670159.82	266843.34
10	670159.82	266846.22
11	670159.82	266849.11
12	670159.82	266852.00
13	670159.82	266854.88
14	670159.82	266857.77
15	670158.98	266841.89
16	670158.98	266844.78
17	670158.98	266847.67
18	670158.98	266850.55
19	670158.98	266853.44
20	670158.98	266856.33
21	670158.98	266859.21
22	670158.15	266840.45
23	670158.15	266843.34
24	670158.15	266846.22
25	670158.15	266849.11
26	670158.15	266852.00
27	670158.15	266854.88
28	670158.15	266857.77
29	670157.32	266841.89
30	670157.32	266844.78
31	670157.32	266847.67
32	670157.32	266850.55
33	670157.32	266853.44
34	670157.32	266856.33
35	670157.32	266859.21
36	670156.48	266840.45
37	670156.48	266843.34
38	670156.48	266846.22
39	670156.48	266849.11
40	670156.48	266852.00
41	670156.48	266854.88
42	670156.48	266857.77
43	670155.65	266841.89
44	670155.65	266844.78
45	670155.65	266847.67
46	670155.65	266850.55
47	670155.65	266853.44
48	670155.65	266856.33
49	670155.65	266859.21
50	670154.82	266840.45
51	670154.82	266843.34
52	670154.82	266846.22
53	670154.82	266849.11
54	670154.82	266852.00
55	670154.82	266854.88
56	670154.82	266857.77
57	670153.98	266841.89
58	670153.98	266844.78
59	670153.98	266847.67
60	670153.98	266850.55
61	670153.98	266853.44
62	670153.98	266856.33
63	670153.98	266859.21
64	670153.15	266840.45
65	670153.15	266843.34
66	670153.15	266846.22
67	670153.15	266849.11
68	670153.15	266852.00
69	670153.15	266854.88
70	670153.15	266857.77
71	670152.32	266841.89
72	670152.32	266844.78
73	670152.32	266847.67
74	670152.32	266850.55
75	670152.32	266853.44

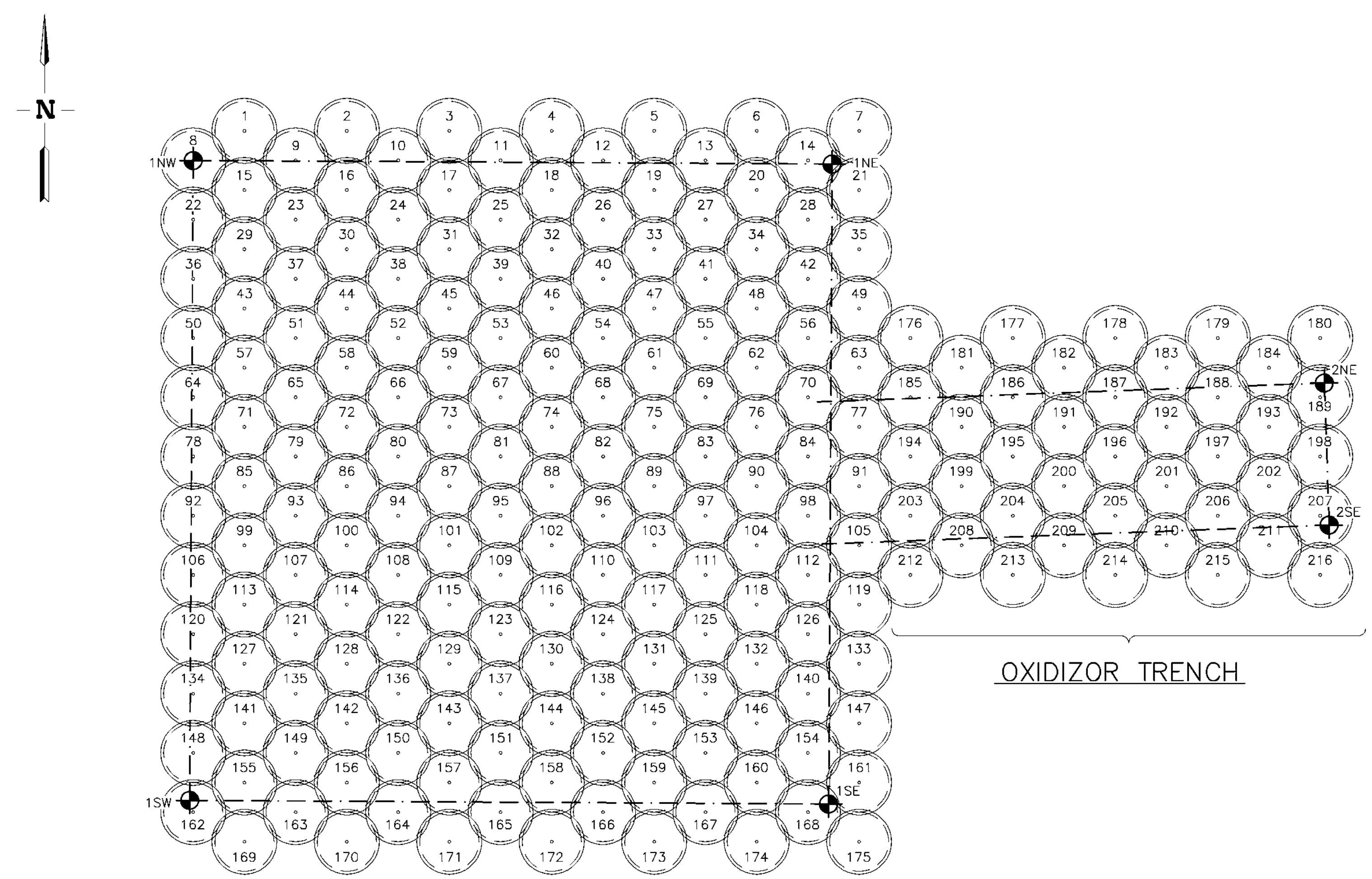
CONTINUED LOWER LEFT

76	670152.32	266856.33
77	670152.32	266859.21
78	670151.48	266840.45
79	670151.48	266843.34
80	670151.48	266846.22
81	670151.48	266849.11
82	670151.48	266852.00
83	670151.48	266854.88
84	670151.48	266857.77
85	670150.65	266841.89
86	670150.65	266844.78
87	670150.65	266847.67
88	670150.65	266850.55
89	670150.65	266853.44
90	670150.65	266856.33
91	670150.65	266859.21
92	670149.82	266840.45
93	670149.82	266843.34
94	670149.82	266846.22
95	670149.82	266849.11
96	670149.82	266852.00
97	670149.82	266854.88
98	670149.82	266857.77
99	670148.98	266841.89
100	670148.98	266844.78
101	670148.98	266847.67
102	670148.98	266850.55
103	670148.98	266853.44
104	670148.98	266856.33
105	670148.98	266859.21
106	670148.15	266840.45
107	670148.15	266843.34
108	670148.15	266846.22
109	670148.15	266849.11
110	670148.15	266852.00
111	670148.15	266854.88
112	670148.15	266857.77
113	670147.32	266841.89
114	670147.32	266844.78
115	670147.32	266847.67
116	670147.32	266850.55
117	670147.32	266853.44
118	670147.32	266856.33
119	670147.32	266859.21
120	670146.48	266840.45
121	670146.48	266843.34
122	670146.48	266846.22
123	670146.48	266849.11
124	670146.48	266852.00
125	670146.48	266854.88
126	670146.48	266857.77
127	670145.65	266841.89
128	670145.65	266844.78
129	670145.65	266847.67
130	670145.65	266850.55
131	670145.65	266853.44
132	670145.65	266856.33
133	670145.65	266859.21
134	670144.82	266840.45
135	670144.82	266843.34
136	670144.82	266846.22
137	670144.82	266849.11
138	670144.82	266852.00
139	670144.82	266854.88
140	670144.82	266857.77
141	670143.98	266841.89
142	670143.98	266844.78
143	670143.98	266847.67
144	670143.98	266850.55
145	670143.98	266853.44
146	670143.98	266856.33
147	670143.98	266859.21
148	670143.15	266840.45
149	670143.15	266843.34
150	670143.15	266846.22
151	670143.15	266849.11
152	670143.15	266852.00
153	670143.15	266854.88

CONTINUED LOWER LEFT

154	670143.15	266857.77
155	670142.32	266841.89
156	670142.32	266844.78
157	670142.32	266847.67
158	670142.32	266850.55
159	670142.32	266853.44
160	670142.32	266856.33
161	670142.32	266859.21
162	670141.48	266840.45
163	670141.48	266843.34
164	670141.48	266846.22
165	670141.48	266849.11
166	670141.48	266852.00
167	670141.48	266854.88
168	670141.48	266857.77
169	670140.65	266841.89
170	670140.65	266844.78
171	670140.65	266847.67
172	670140.65	266850.55
173	670140.65	266853.44
174	670140.65	266856.33
175	670140.65	266859.21
176	670154.82	266860.66
177	670154.82	266863.54
178	670154.82	266866.43
179	670154.82	266869.32
180	670154.82	266872.20
181	670153.98	266862.10
182	670153.98	266864.99
183	670153.98	266867.87
184	670153.98	266870.76
185	670153.15	266860.66
186	670153.15	266863.54
187	670153.15	266866.43
188	670153.15	266869.32
189	670153.15	266872.20
190	670152.32	266862.10
191	670152.32	266864.98
192	670152.32	266867.87
193	670152.32	266870.76
194	670151.48	266860.66
195	670151.48	266863.54
196	670151.48	266866.43
197	670151.48	266869.32
198	670151.48	266872.20
199	670150.65	266862.10
200	670150.65	266864.99
201	670150.65	266867.87
202	670150.65	266870.76
203	670149.82	266860.66
204	670149.82	266863.54
205	670149.82	266866.43
206	670149.82	266869.32
207	670149.82	266872.20
208	670148.98	266862.10
209	670148.98	266864.99
210	670148.98	266867.87
211	670148.98	266870.76
212	670148.15	266860.66
213	670148.15	266863.54
214	670148.15	266866.43
215	670148.15	266869.32
216	670148.15	266872.20

REV	DESCRIPTION	EFFECTIVE DATE:
	REVISIONS	



COLD TEST PIT – NORTH

SCALE: 1"=2.0'

BASED ON 1981 SITE SPECIFIC COORDINATES

NOTES

1. THIS SKETCH PROVIDES NORTHING AND EASTING COORDINATES FOR 216 HOLES TO BE DRILLED IN THE COLD TEST PIT – NORTH.
2. THE COLD TEST PIT – NORTH IS A PIT THAT HAS BEEN PREPARED WITH WASTE CONTAINERS AT VARIOUS LEVELS CONTAINING WASTE SIMULATES OF VARIOUS TYPES.
3. THE PURPOSE OF INSITU GROUTING THIS PIT IS TO PROVIDE TRAINING OF EQUIPMENT AND PROCEDURES BEFORE THE WORK PROGRESSES INTO SOIL VAULTS AND TRENCHES IN THE SDA.

FOR DRAWING INDEX SEE DRAWING NO.

SCALE: 1" = 2.0'

DESIGN PHASE: CONCEPTUAL
SAFETY CATEGORY: CG

SUBCONTRACT NO. N/A
REQUESTER: FRANK WEBBER
DESIGN: PJ BUNNELL
DRAWN: DH MANWILL/R PENCE
PROJECT NO. 23833
SPEC CODE
FOR REVIEW/APPROVAL SIGNATURES SEE BAR NO.
EFFECTIVE DATE:

INEEL Idaho National Engineering & Environmental Laboratory BECHTEL BWXT IDAHO, LLC

OU 7-13/14 ISG PHASE TWO

ENLARGED COLD TEST PIT – NORTH AND COORDINATE TABLE

SIZE D CAGE CODE 01MF3 INDEX CODE NUMBER AREA 098 TYPE 0200 CL DISC. 090 DWG- REV

SCALE: NOTED SHEET FIG–2

FWT-01-REV 3.3

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REVISIONS		
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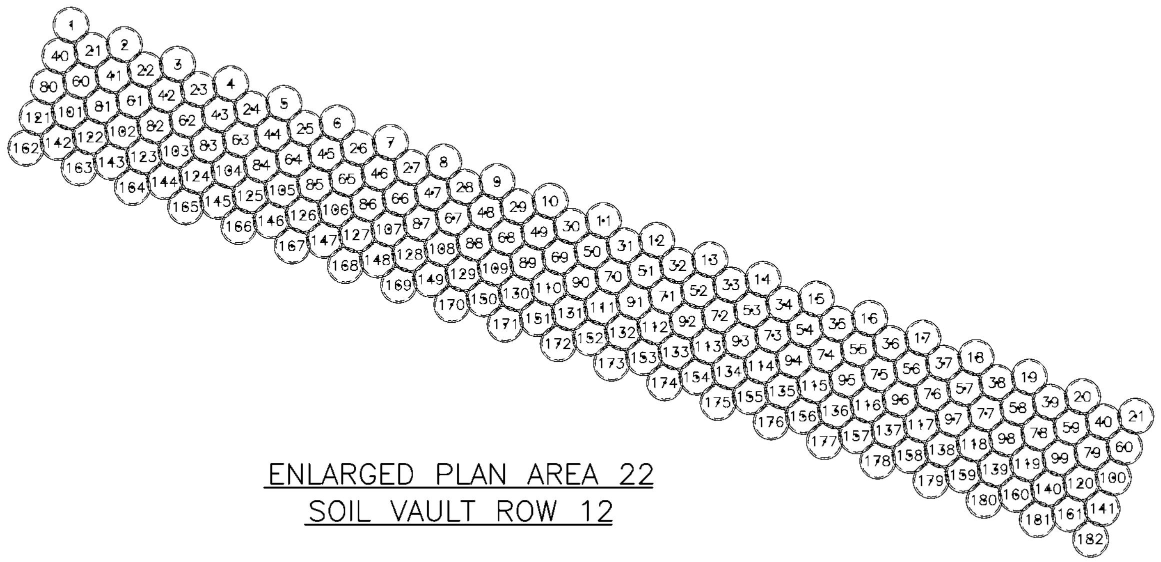

ENLARGED PLAN AREA 22
SOIL VAULT ROW 12

COORDINATE TABLE

DATUM:
HORIZONTAL:

CONTINUED LOWER LEFT

NO.	NORTHING	EASTING
1	TO BE DETERMINED	
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42		
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44		
45		
46		
47	TO BE DETERMINED	
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96	TO BE DETERMINED	
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142		
143		
144		
145	TO BE DETERMINED	
146		
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182		

COORDINATE TABLE

DATUM:
HORIZONTAL:

NO.	NORTHING	EASTING
1	TO BE DETERMINED	
2		
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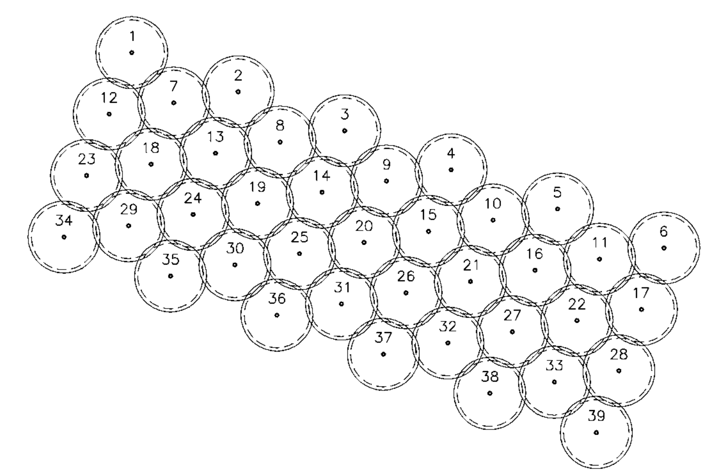


ENLARGED PLAN AREA 15
SOIL VAULT ROW 14

NOTES

1. SOIL VAULT ROW 12 AND SOIL VAULT ROW 14 ARE AT THE TOP OF THE LIST IN THE SEQUENCE TABLE SHOWN ON FIGURE 1. THESE FIRGURES SHOW THE CONFIGURATION OF THE HOLES TO BE DRILLED AND INJECTED WITH GROUT.
2. THE NORTHING AND EASTING DATA IN THE CORDINATE TABLES ARE YET TO BE DETERMINED BECAUSE THE ACTUAL POSITIONS OF THESE SOIL VAULT ROWS IN THESE RESPECTIVE AREAS IS YET TO BE PRECISELY DEFINED.
3. WHEN THE POSITIONS ARE DEFINED, THE NORTHINGS AND EASTING COORDINATE DATA WILL BE PROVIDED TO THE SUBCONTRACTOR FOR ALL THE SOIL VAULT ROWS AND TRENCHES IN THE SEQUENCE TABLE.

FOR DRAWING INDEX SEE DRAWING NO.
SUBCONTRACT NO.
NO SCALE
REQUESTER: FRANK WEBBER
DESIGN: P. BUNNELL
DRAWN: R. PENCE
PROJECT NO. 23833
SPCL CODE
DESIGN PHASE: CONCEPTUAL
FOR REVIEW/APPROVAL SIGNATURES
SEE BAR NO.
SAFETY CATEGORY: CG
EFFECTIVE DATE:

INEEL Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

OU 7-13/14 ISG PHASE 2
ENLARGED PLANS
AREA 22 SVR-12 AND AREA 15 SVR-14

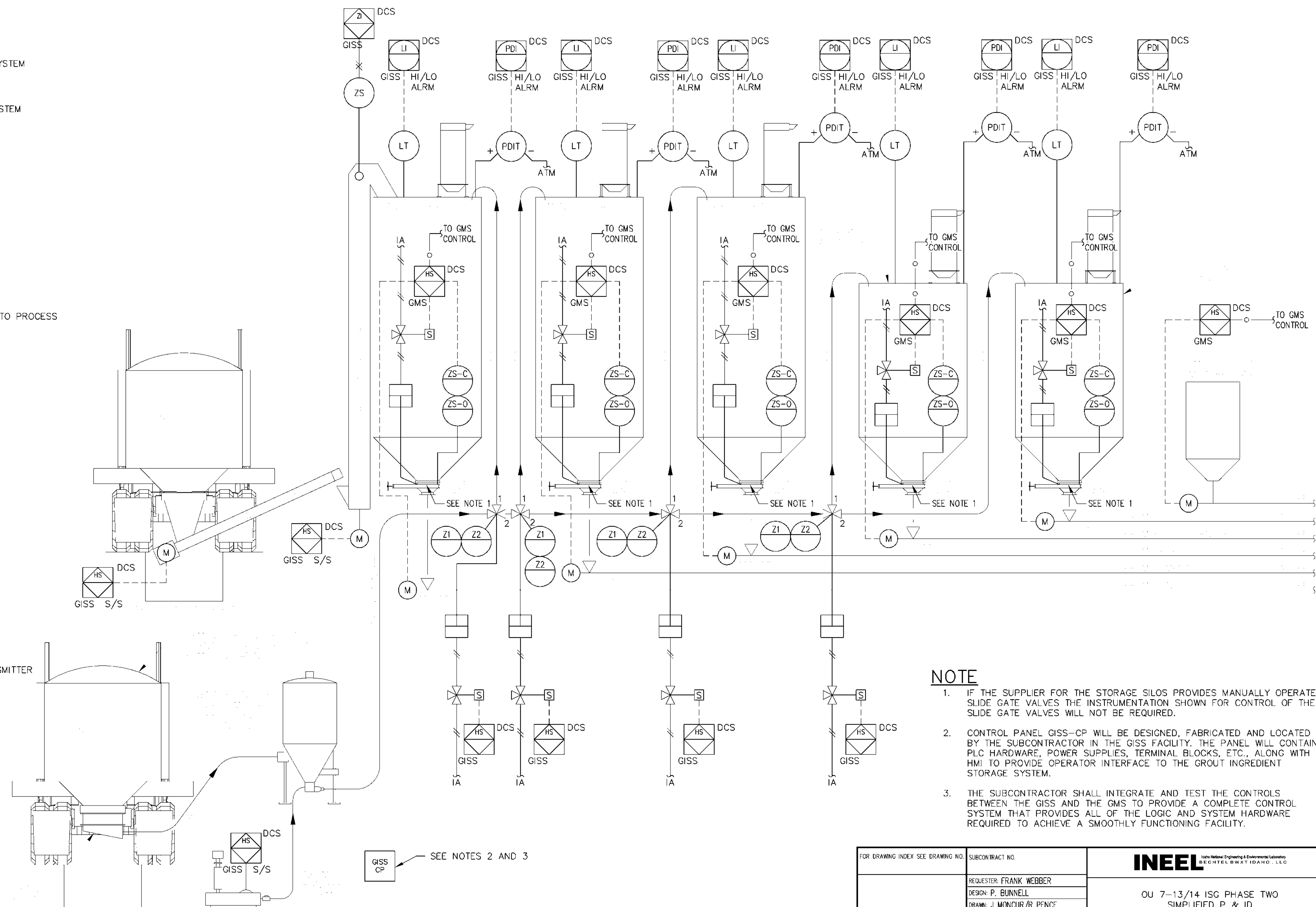
SIZE D CAGE CODE 01MF3 INDEX CODE NUMBER AREA 098 TYPE 0100 CL 01 ORG 090 DWG- REV
SCALE: NONE
SHEET FIG-3

LEGEND

XX	FIELD MOUNTED INSTRUMENT
XXX	SHARED DISPLAY ANALOG/CONTROL SYSTEM
XXX	SHARED DISPLAY DIGITAL CONTROL SYSTEM
	ACTUATOR
	3-WAY VALVE
S	SOLENOID ACTUATOR
M	MOTOR
	START/STOP PUSHBUTTON
	ELECTRIC BINARY SIGNAL (ON/OFF)
	INSTRUMENT SUPPLY OR CONNECTION TO PROCESS
	PNEUMATIC SIGNAL
	ELECTRIC SIGNAL

ABBREVIATIONS

A	ANALYSIS
ALRM	ALARM
ATM	ATMOSPHERE
C	CLOSE
CP	CONTROL PANEL
DCS	DISTRIBUTED CONTROL SYSTEM
GHPS	GROUT HIGH-PRESSURE SUBSYSTEM
GIPS	GROUT INJECTION POSITIONING SYSTEM
GISS	GROUT INGREDIENT STORAGE SYSTEM
GLPS	GROUT LOW-PRESSURE SUBSYSTEM
GMS	GROUT MIXING SYSTEM
HI	HIGH
HOA	HAND-OFF-AUTO
HS	HAND SWITCH
IA	INSTRUMENT AIR
LI	LEVEL INDICATOR
LIA	LEVEL INDICATOR/ALARM
LIT	LEVEL INDICATOR TRANSMITTER
LO	LOW
LT	LEVEL TRANSMITTER
O	OPEN
PDI	PRESSURE DIFFERENTIAL INDICATOR
PDIT	PRESSURE DIFFERENTIAL INDICATOR/TRANSMITTER
PIA	PRESSURE INDICATOR ALARM
PIT	PRESSURE INDICATOR TRANSMITTER
PTZ	PAN-TILT-ZOOM
Q	QUANTITY
RMF	REMOTE MONITORING FACILITY
S	SOLENOID
S/S	START/STOP
Z1	POSITION SWITCH - POSITION 1
Z2	POSITION SWITCH - POSITION 2
ZI	POSITION INDICATION
ZS-C	POSITION SWITCH - CLOSED
ZS-O	POSITION SWITCH - OPEN



NOTE

1. IF THE SUPPLIER FOR THE STORAGE SILOS PROVIDES MANUALLY OPERATED SLIDE GATE VALVES THE INSTRUMENTATION SHOWN FOR CONTROL OF THE SLIDE GATE VALVES WILL NOT BE REQUIRED.
2. CONTROL PANEL GISS-CP WILL BE DESIGNED, FABRICATED AND LOCATED BY THE SUBCONTRACTOR IN THE GISS FACILITY. THE PANEL WILL CONTAIN PLC HARDWARE, POWER SUPPLIES, TERMINAL BLOCKS, ETC., ALONG WITH HMI TO PROVIDE OPERATOR INTERFACE TO THE GROUT INGREDIENT STORAGE SYSTEM.
3. THE SUBCONTRACTOR SHALL INTEGRATE AND TEST THE CONTROLS BETWEEN THE GISS AND THE GMS TO PROVIDE A COMPLETE CONTROL SYSTEM THAT PROVIDES ALL OF THE LOGIC AND SYSTEM HARDWARE REQUIRED TO ACHIEVE A SMOOTHLY FUNCTIONING FACILITY.

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE:

FOR DRAWING INDEX SEE DRAWING NO.
SUBCONTRACT NO.
REQUESTER: FRANK WEBBER
DESIGN: P. BUNNELL
DRAWN: J MONCUR/R PENCE
PROJECT NO. 23833
SPCL CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.
EFFECTIVE DATE:
NO SCALE
DESIGN PHASE: CONCEPTUAL
SAFETY CATEGORY: CG

INEEL Idaho National Engineering & Environmental Laboratory BECHTEL BWXT IDAHO, LLC

OU 7-13/14 ISG PHASE TWO
SIMPLIFIED P & ID
GROUT INGREDIENT STORAGE SYSTEM
(DRY INGREDIENT SECTION)

SIZE D CAGE CODE 01MF3 INDEX CODE NUMBER AREA 098 TYPE 0200 CL 28 DISC 090 DWG- REV
SCALE: NONE SHEET FIG-4

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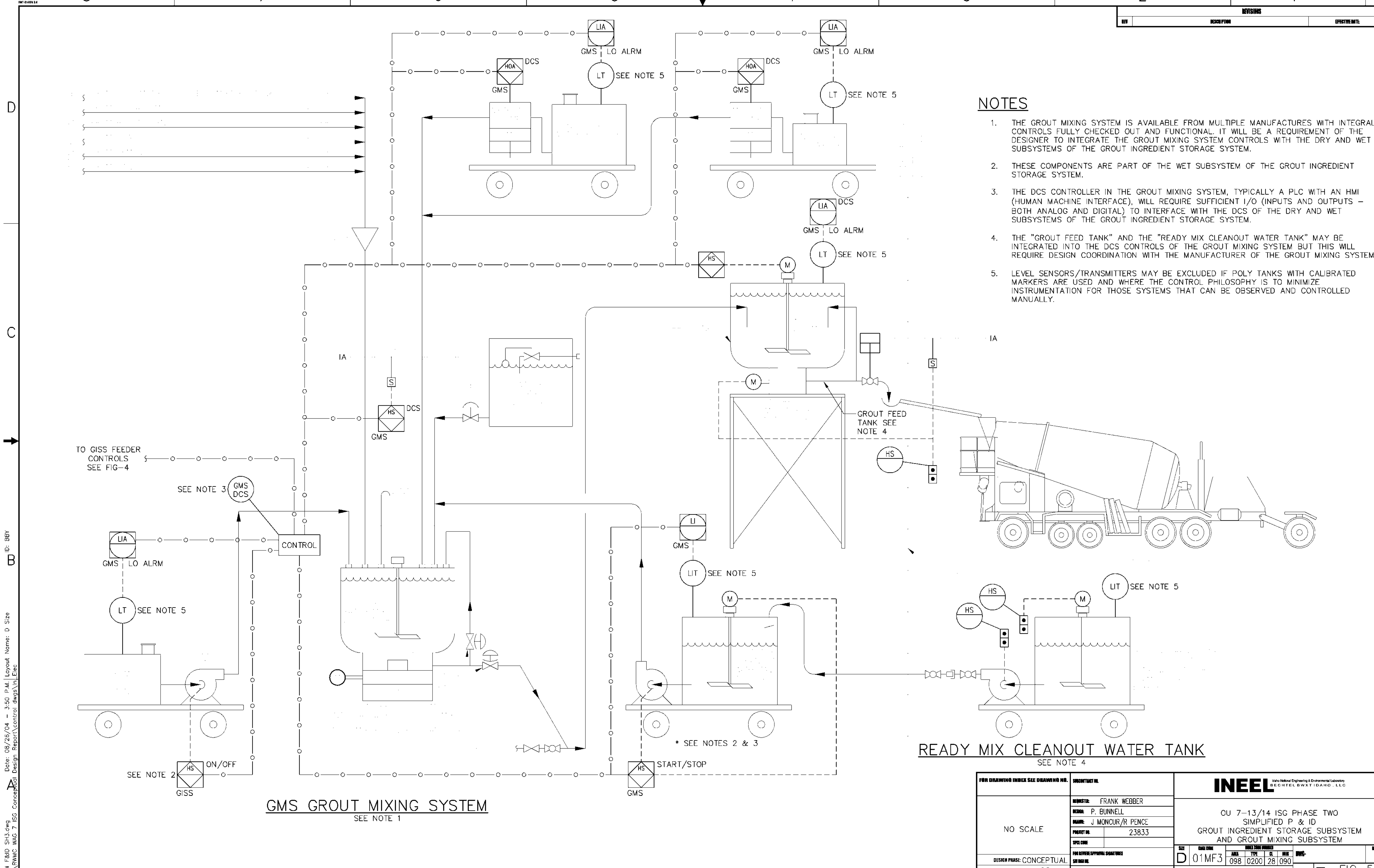
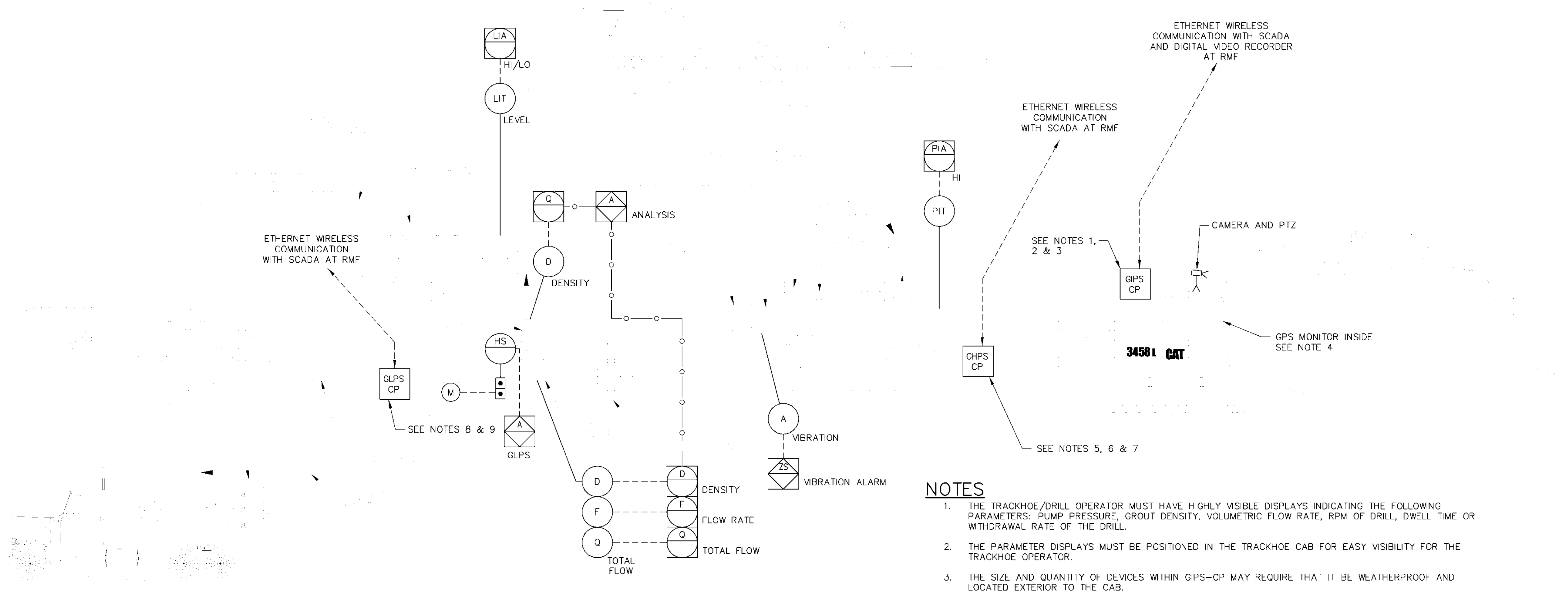


NOTES

1. THE GROUT MIXING SYSTEM IS AVAILABLE FROM MULTIPLE MANUFACTURES WITH INTEGRAL CONTROLS FULLY CHECKED OUT AND FUNCTIONAL. IT WILL BE A REQUIREMENT OF THE DESIGNER TO INTEGRATE THE GROUT MIXING SYSTEM CONTROLS WITH THE DRY AND WET SUBSYSTEMS OF THE GROUT INGREDIENT STORAGE SYSTEM.
2. THESE COMPONENTS ARE PART OF THE WET SUBSYSTEM OF THE GROUT INGREDIENT STORAGE SYSTEM.
3. THE DCS CONTROLLER IN THE GROUT MIXING SYSTEM, TYPICALLY A PLC WITH AN HMI (HUMAN MACHINE INTERFACE), WILL REQUIRE SUFFICIENT I/O (INPUTS AND OUTPUTS – BOTH ANALOG AND DIGITAL) TO INTERFACE WITH THE DCS OF THE DRY AND WET SUBSYSTEMS OF THE GROUT INGREDIENT STORAGE SYSTEM.
4. THE "GROUT FEED TANK" AND THE "READY MIX CLEANOUT WATER TANK" MAY BE INTEGRATED INTO THE DCS CONTROLS OF THE GROUT MIXING SYSTEM BUT THIS WILL REQUIRE DESIGN COORDINATION WITH THE MANUFACTURER OF THE GROUT MIXING SYSTEM.
5. LEVEL SENSORS/TRANSMITTERS MAY BE EXCLUDED IF POLY TANKS WITH CALIBRATED MARKERS ARE USED AND WHERE THE CONTROL PHILOSOPHY IS TO MINIMIZE INSTRUMENTATION FOR THOSE SYSTEMS THAT CAN BE OBSERVED AND CONTROLLED MANUALLY.



NOTES

1. THE TRACKHOE/DRILL OPERATOR MUST HAVE HIGHLY VISIBLE DISPLAYS INDICATING THE FOLLOWING PARAMETERS: PUMP PRESSURE, GROUT DENSITY, VOLUMETRIC FLOW RATE, RPM OF DRILL, DWELL TIME OR WITHDRAWAL RATE OF THE DRILL.
2. THE PARAMETER DISPLAYS MUST BE POSITIONED IN THE TRACKHOE CAB FOR EASY VISIBILITY FOR THE TRACKHOE OPERATOR.
3. THE SIZE AND QUANTITY OF DEVICES WITHIN GIPS-CP MAY REQUIRE THAT IT BE WEATHERPROOF AND LOCATED EXTERIOR TO THE CAB.
4. THE GPS MONITOR MUST BE POSITIONED IN THE TRACKHOE CAB FOR EASY VISIBILITY TO THE TRACKHOE OPERATOR.
5. CONTROL PANEL GHPS-CP MUST BE WEATHERPROOF AND POSITIONED TO PROVIDE EASY ACCESS TO OPERATIONS AND MAINTENANCE PERSONNEL.
6. THE HIGH-PRESSURE PUMP OPERATOR MUST HAVE HIGHLY VISIBLE DISPLAYS INDICATING THE FOLLOWING PARAMETERS: PUMP PRESSURE AND VOLUMETRIC FLOW RATE.
7. THE HIGH-PRESSURE PUMP OPERATOR WILL ADJUST GEARS AND THROTTLE TO MAINTAIN UNIFORM PRESSURE BUT MUST BE ABLE TO INCREASE PRESSURE IF DIRECTED BY THE TRACKHOE/DRILL OPERATOR.
8. CONTROL PANEL GLPS-CP MUST BE WEATHERPROOF AND POSITIONED TO PROVIDE EASY ACCESS TO OPERATIONS AND MAINTENANCE PERSONNEL.
9. THE LOW-PRESSURE PUMP OPERATOR MUST HAVE HIGHLY VISIBLE DISPLAYS INDICATION THE FOLLOWING PARAMETERS: DENSITY OF RE-CIRCULATING GROUT, DENSITY OF GROUT FEEDING THE HIGH-PRESSURE PUMP, VOLUMETRIC FLOW RATE OF GROUT, RATIO OF DENSITIES OF RE-CIRCULATED GROUT TO PUMPED GROUT, LEVEL OF GROUT IN THE GROUT FEED HOPPER.

NO SCALE

DESIGN PHASE: CONCEPTUAL
SAFETY CATEGORY: CG

FRANK WEBBER
AL GRAM
J MONCUR/R PENCE
23833

INEEL

OU 7-13/14 ISG PHASE TWO
SIMPLIFIED P & ID
GROUT LOW PRESSURE, HIGH PRESSURE SUBSYSTEM
AND INJECTION POSITIONING SYSTEM

D 01MF3 098 0200 28 090

SCALE: NONE

FIG-6

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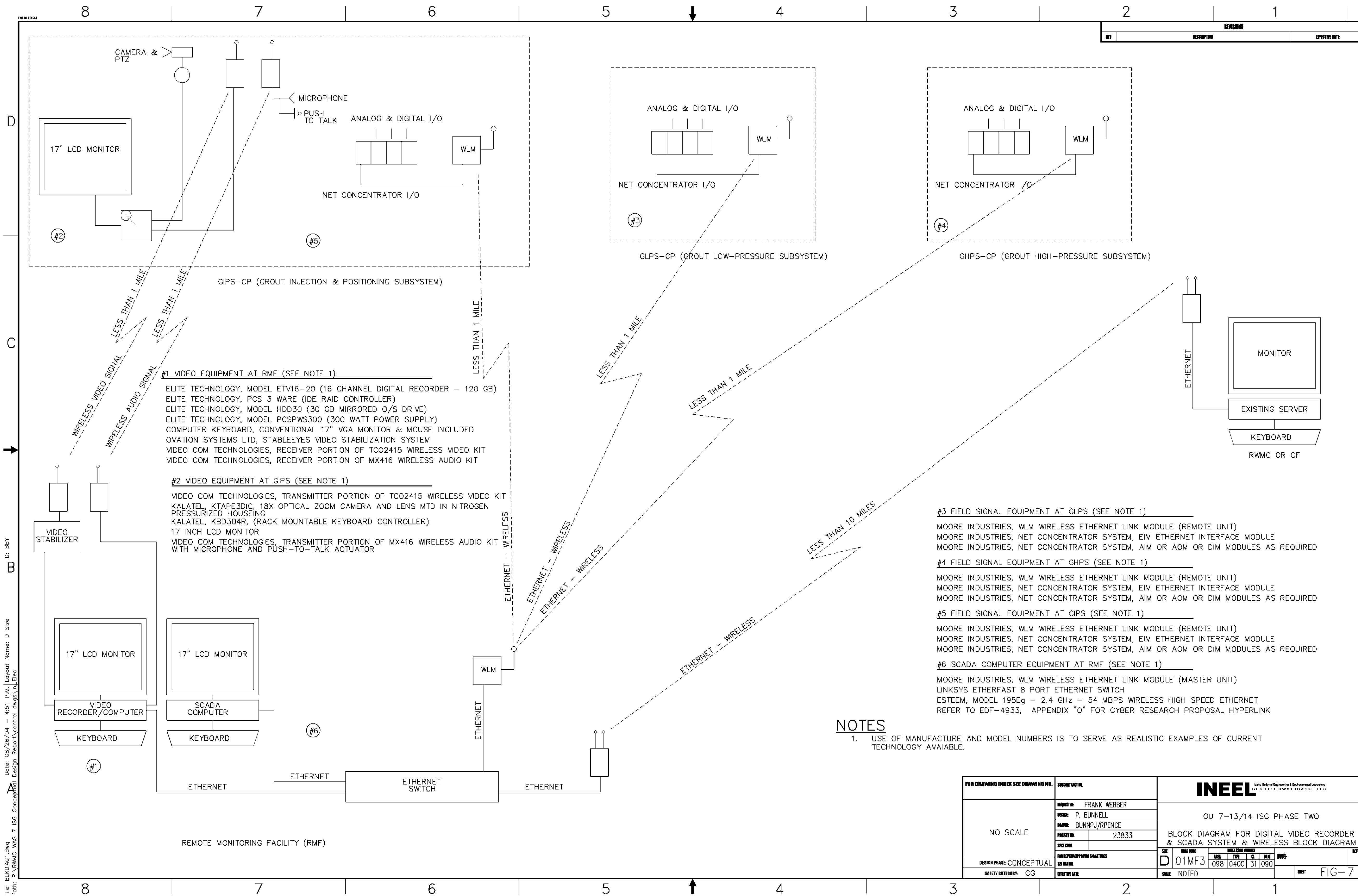
CAMERA & PTZ
MICROPHONE
PUSH TO TALK
ANALOG & DIGITAL I/O
WLM
NET CONCENTRATOR I/O
17" LCD MONITOR
#2
#5
GIPS-CP (GROUT INJECTION & POSITIONING SUBSYSTEM)
#3
GLPS-CP (GROUT LOW-PRESSURE SUBSYSTEM)
#4
GHPS-CP (GROUT HIGH-PRESSURE SUBSYSTEM)
LESS THAN 1 MILE
LESS THAN 10 MILES
WIRELESS VIDEO SIGNAL
WIRELESS AUDIO SIGNAL
ETHERNET – WIRELESS
MONITOR
EXISTING SERVER
KEYBOARD
RWMC OR CF
ETHERNET
#1 VIDEO EQUIPMENT AT RMF (SEE NOTE 1)
ELITE TECHNOLOGY, MODEL ETV16-20 (16 CHANNEL DIGITAL RECORDER – 120 GB)
ELITE TECHNOLOGY, PCS 3 WARE (IDE RAID CONTROLLER)
ELITE TECHNOLOGY, MODEL HDD30 (30 GB MIRRORED O/S DRIVE)
ELITE TECHNOLOGY, MODEL PCSPWS300 (300 WATT POWER SUPPLY)
COMPUTER KEYBOARD, CONVENTIONAL 17" VGA MONITOR & MOUSE INCLUDED
OVATION SYSTEMS LTD, STABLEEYES VIDEO STABILIZATION SYSTEM
VIDEO COM TECHNOLOGIES, RECEIVER PORTION OF TCO2415 WIRELESS VIDEO KIT
VIDEO COM TECHNOLOGIES, RECEIVER PORTION OF MX416 WIRELESS AUDIO KIT
#2 VIDEO EQUIPMENT AT GIPS (SEE NOTE 1)
VIDEO COM TECHNOLOGIES, TRANSMITTER PORTION OF TCO2415 WIRELESS VIDEO KIT
KALATEL, KTAPE3DIC, 18X OPTICAL ZOOM CAMERA AND LENS MTD IN NITROGEN PRESSURIZED HOUSEING
KALATEL, KBD304R, (RACK MOUNTABLE KEYBOARD CONTROLLER)
17 INCH LCD MONITOR
VIDEO COM TECHNOLOGIES, TRANSMITTER PORTION OF MX416 WIRELESS AUDIO KIT WITH MICROPHONE AND PUSH-TO-TALK ACTUATOR
#3 FIELD SIGNAL EQUIPMENT AT GLPS (SEE NOTE 1)
MOORE INDUSTRIES, WLM WIRELESS ETHERNET LINK MODULE (REMOTE UNIT)
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, EIM ETHERNET INTERFACE MODULE
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, AIM OR AOM OR DIM MODULES AS REQUIRED
#4 FIELD SIGNAL EQUIPMENT AT GHPS (SEE NOTE 1)
MOORE INDUSTRIES, WLM WIRELESS ETHERNET LINK MODULE (REMOTE UNIT)
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, EIM ETHERNET INTERFACE MODULE
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, AIM OR AOM OR DIM MODULES AS REQUIRED
#5 FIELD SIGNAL EQUIPMENT AT GIPS (SEE NOTE 1)
MOORE INDUSTRIES, WLM WIRELESS ETHERNET LINK MODULE (REMOTE UNIT)
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, EIM ETHERNET INTERFACE MODULE
MOORE INDUSTRIES, NET CONCENTRATOR SYSTEM, AIM OR AOM OR DIM MODULES AS REQUIRED
#6 SCADA COMPUTER EQUIPMENT AT RMF (SEE NOTE 1)
MOORE INDUSTRIES, WLM WIRELESS ETHERNET LINK MODULE (MASTER UNIT)
LINKSYS ETHERFAST 8 PORT ETHERNET SWITCH
ESTEEM, MODEL 195Eg – 2.4 GHz – 54 MBPS WIRELESS HIGH SPEED ETHERNET
REFER TO EDF-4933, APPENDIX "O" FOR CYBER RESEARCH PROPOSAL HYPERLINK
VIDEO STABILIZER
VIDEO RECORDER/COMPUTER
SCADA COMPUTER
#1
#6
ETHERNET SWITCH
REMOTE MONITORING FACILITY (RMF)
NOTES
1. USE OF MANUFACTURE AND MODEL NUMBERS IS TO SERVE AS REALISTIC EXAMPLES OF CURRENT TECHNOLOGY AVAIABLE.
REVISIONS
NO SCALE
FRANK WEBBER
P. BUNNELL
BUNNPJ/RPENCE
23833
DESIGN PHASE: CONCEPTUAL
SAFETY CATEGORY: CG
INEEL
OU 7-13/14 ISG PHASE TWO
BLOCK DIAGRAM FOR DIGITAL VIDEO RECORDER & SCADA SYSTEM & WIRELESS BLOCK DIAGRAM
D 01MF3 098 0400 31 090
NOTED
FIG-7

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Appendix E

Concept of Grout Returns and Efficiencies of Injecting Grout at High Pressures

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Appendix E

Concept of Grout Returns and Efficiencies of Injecting Grout at High Pressures

After the drill bit has drilled down to the target depth of the pit or trench, high-pressure grout injection begins. The purpose in injecting the grout under high pressure (8500 psig) is two-fold:

1. Erosion of the soil with a high kinetic energy jet of grout at ambient pressure. (The soil matrix is disrupted, mixed with grout, and excess material flows back to the surface.)

2. Because the drill stem is rotating while the grout is injected, a column of grout mixed with soil and waste is formed as the drill stem is withdrawn. The resultant multiple columns form an array of columns arranged in close proximity to serve as a monolithic structure to support an overlying earthen cap to be applied later.

The maximum achievable efficiency is maintained if a balance is struck between the RPM of the drill stem and the volume of grout that is ejected through the orifices. In the case of this project, the volume of grout for each rotation of the drill stem will be a wafer of grout whose thickness is described by the diverging envelope of the grout as it mixes with the soil and waste to a radius of approximately 12 inches from the drill stem. As the orifices erode and become enlarged, a greater volume of grout will be ejected through the jet orifices. This will result in an increased amount of excess material flowing back to the surface as well as a less efficient mixing of the grout with the soil, which could compromise the strength of the grout columns and waste grout.

It is important to collect some kind of data that relates the volume of grout that returns to the surface matched against the volume of grout that is ejected into the hole. This kind of data, trended against the instantaneous depth of the drill stem, the output pressure of the grout pump, and the density of the grout, properly configured and displayed will give understanding of the following conditions:

1. Orifice erosion of the grout jets

2. Presence of hard pan or rock

3. Large waste voids.

It has been discussed that this record can be kept manually via visual observation and note taking by an observer essentially dedicated to the task. If it is done this way, the observer will have to keep his or her attention focused on the drill bit, the depth of the drill bit (estimation), and the surface of the ground around the drill bit for the 5 to 6 minutes that elapse during drill withdrawal and grout injection. This will have to be done consistently for each of the hundreds of thousands of holes spanning the duration of the grout injection process every shift of every working day for each year it is in operation. This one task alone could easily consume the dedicated efforts of one individual for each drill rig for each shift because it is not likely to be a task that could be lumped in with other responsibilities. Present thinking is that it will take approximately 10 minutes from start to finish to drill and inject grout into each hole. The need to stay focused on observing the operation and recording and estimating the grout returns manually will be a meticulous and boring task with high probability of error. It is very probable that the digital video recording system will pay for itself (approximately $30,000) in a year or less.

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Appendix F

Video Recording of Grout Returns

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Appendix F

Video Recording of Grout Returns

An automated alternative for recording the grout return data is to utilize digital video recording (DVR). This alternate will require a camera mounted on or in the trackhoe cab. It may be preferable to mount the camera on top of the trackhoe cab to obtain a better-angled view of the surface of the ground where the hole is being drilled. This will depend upon whether or not the lower structure of the drill rig blocks the view at that angle.

An alternative mounting of the camera would be inside the trackhoe cab, down low near the operator's knees or feet if there is a window at that level.

If mounted outside on the trackhoe cab, the camera will require a weatherproof housing, possibly pressurized with nitrogen.

Additional equipment required would be a digital recorder that is integral to a computer workstation with special video software and hardware to control and store the digital video images. A typical system would be capable of multiplexing up to 16 channels of video (16 cameras) simultaneously.

A wireless transmitter-receiver combination with a video stabilizer module for each camera would be required to send and receive a continuous stream of video images.

In order to include an audio channel, a separate audio transmitter-receiver would also be required.

The operational scenario of such a system is described below (see Figure 7 in Appendix D for a block diagram of this system with an equipment list).

A video monitor and PTZ (Pan, Tilt, Zoom) control station would be mounted inside the trackhoe cab. A color video camera (in a weatherproof enclosure, if mounted outside) with PTZ, would be adjusted by the trackhoe operator just after or just before the drill rig is positioned for the drilling of the next hole. The PTZ controls for the camera adjustment would be custom mounted beneath the video monitor. The operator would flip a switch to the "On" position before adjusting the PTZ. The camera video signal via the wireless transmitter and receiver would enable digital video recording at the RMF located outside the SDA fenced area in a mobile trailer. The operator would switch on a microphone and transmit voice data in parallel with the video signal to a separate audio input at the recorder to provide information as applicable at the time, such as the tag number of the hole. The drilling of the hole would proceed and would be digitally recorded with a date and time stamp at configurable frames per second rate (five frames per second is recommended). Assuming there is adequate light, and the lens has been optically zoomed to a favorable view, a very good video record of the grout returns for each hole should be possible. With some experimentation and training, it should be possible to estimate the amount of grout that has returned to the surface.

In the event that some grout injection work takes place in twilight or nighttime, it will be necessary to have auxiliary lighting that is directed towards the drill rig. The lighting could be mounted on the trackhoe, probably up on top of the cab.

The video recording equipment in the mobile monitoring station would consist of the wireless video receiver with antenna, video stabilizer module, wireless audio receiver with antenna, digital recorder, a Raid controller card with a “mirrored” hard drive that would give redundancy in the event of hard drive failure, a hot-swappable power supply, computer keyboard, and video monitor.

This equipment would be mounted in a compact rack configuration. The system described here is capable of up to 16 video channels, all transmitting simultaneously. The cost for 16 channels as opposed to a four-channel system is minimal and is recommended because the 16-channel configuration is sized to accommodate the Raid controller and “mirrored” hard drive. Multiple channels provide the capability to capture video records of other phases or segments of the grouting operation, such as the grout high-pressure and low-pressure subsystems. This data could be useful for training or researching what may have happened in an abnormal event. It should be noted that each camera will require its own video transmitter-receiver with antenna.

An important fact to consider concerning digital video recording is that there are no videotapes to manage and there is no waiting around to view the video record of interest. It is instantly available by selection of date and time or other configurable search parameters. If the digital video recorder-computer is wirelessly connected to the intranet, all of the data can be periodically downloaded to a server on a shift, daily, or weekly basis or backed up on a writeable DVD.

Appendix G

Purpose for Monitoring the Flow of Grout

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Appendix G

Purpose for Monitoring the Flow of Grout

There are numerous advantages to monitoring grout flow, three primary reasons are:

- Trending of wear and tear on the drill orifices.
- For trending and comparison of grout volume into each hole to ascertain conditions in the pit or trench. For example, the total volume of grout in a given hole will be dependent upon soil conditions, the presence or absence of rock, the presence of waste material in its different forms, or absence or presence of large solid waste containers with empty voids.
- Once the average volume of grout for each hole has been determined and it is continually monitored and quantified for each hole, this will amount to significant data in the effort to analyze the integrity of each grout column and give some indication of waste quantity and/or type in different sectors of each pit or trench.

Appendix H

Methods for Monitoring the Flow of Grout

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Appendix H

Methods for Monitoring the Flow of Grout

1. Volumetric flow utilizing a high-pressure pump of known volumetric stroke.

A positive displacement pump that discharges a known volume of a non-compressible fluid with each stroke of the pump provides a simple way to quantify the total volumetric flow of grout into each hole. All that needs to be done is to attach or couple some sort of device on the pump that will output an electronic pulse to a counting device. For example, if it has been determined that each stroke of the pump is equal to one gallon of fluid, then the total number of pulses will be equal to the total gallons discharged by the pump. Of course, if the pump is allowed to idle when grout flow to the inlet is denied, then the counter should ignore the count pulses.

Counting the stroke pulses of the pump can be termed an "inferential" method of determining the volumetric flow rate of the fluid that is being pumped (i.e., it is not a direct method of measuring the volumetric flow). If the total volumetric flow of the fluid is the parameter of interest, this inferential method has some problems associated with it. For example, what if there is a significant quantity of air bubbles entrained in the grout? Or, what if there are slugs of fluid interspersed with large air bubbles? The presence of air in either case will give indeterminate errors in computing the total volumetric flow.

In addition to the problem of generating data with indeterminate errors in the computation of total volumetric flow caused by the presence of unknown quantities of air, is the danger caused by the presence of the compressed air in the highly pressurized fluid in the high-pressure outlet piping and fittings. If there is a way to determine the amount of air in the grout and trend this parameter in real time, it could be monitored and serve as a trigger to annunciate an alarm and shut down the high-pressure pump when a target threshold is reached.

2. Volumetric flow utilizing a high-pressure turbine flowmeter.

Volumetric flow of the grout can be accomplished with the use of a turbine flowmeter, but the life of one of these devices is limited when measuring cementacious grout. This device communicates with external counting devices via magnetic pickups that provide a pulse to the counter. The use of this type of device is not recommended for this application. One manufacturer that offers this type of device is Hoffer Flow Controls, Inc., Elizabeth City, NC 27906-2145, Tel: 800-628-4584, email: info@hofferflow.com, web site: www.hofferflow.com. For information on Hoffer's Wingnut High-Pressure Turbine Flow Meter see the website http://www.hoefferflow.com/products/datashts/wingnut.pdf

3. Volumetric-mass flow utilizing a Coriolis sensor in the inlet piping that feeds the high-pressure pump.

Current state-of-the-art technology has provided volumetric-mass flow and density meters with increased reliability, even with two-phase flow or partial empty sensing tube conditions. The measurement of mass flow and volumetric flow directly, rather than inferentially as has been done historically, has eliminated the inaccuracies of multiple process measurements associated with volumetric flow devices. Coriolis mass flow and density meters are capable of measuring true volumetric flow in conventional engineering units because they continuously measure mass flow and density simultaneously.

For information on flow sensors and their product specifications, see: http://resource.invensys.com/instrumentation/specifications/pss/1/1_2b1a.pdf.

For information on Coriolis transmitters and their product specification, see http://resource.invensys.com/instrumentation/specifications/pss/1/1_2b7a.pdf.

For an online flow sensor sizing program, see: http://www.flowexpertpro.com/formcustomerrepresentative.aspx.

The following output tables provide information on the results of using the flow sensor sizing program.

Invensys Foxboro
FlowExpertPro.com Results

Customer/Representative

	Customer		Representative
Customer Name:	Bechtel BBWI	Company:	
Contact Name:	Paul Bunnell	Sales Person:	
Address:	2525 Fremont Ave	Sales Order Number:	
	Idaho Falls, Idaho 83406	Phone Number:	
		Fax Number:	
Phone Number:	208-526-3389	Cellular Number:	
Fax Number:	208-526-2681	E-Mail Address:	
E-Mail Address:	bunnpj@inel.gov		

Process Data

Meter Type:	Coriolis
Fluid Type:	Liquid
Fluid:	Other (Grout)
Tag Number:	Grout-vis-2
Tag Name:	

	Minimum Startup	Normal	Maximum	
Flow Rate:	2.00	24.00	26.00	USgal/min
Temperature:	50.0	60.0	70.0	°F
Pressure:	25.0	50.0	100.0	psig
Density/SG:		2.00000		SG (liquid)
Viscosity:		2.000		centipoise

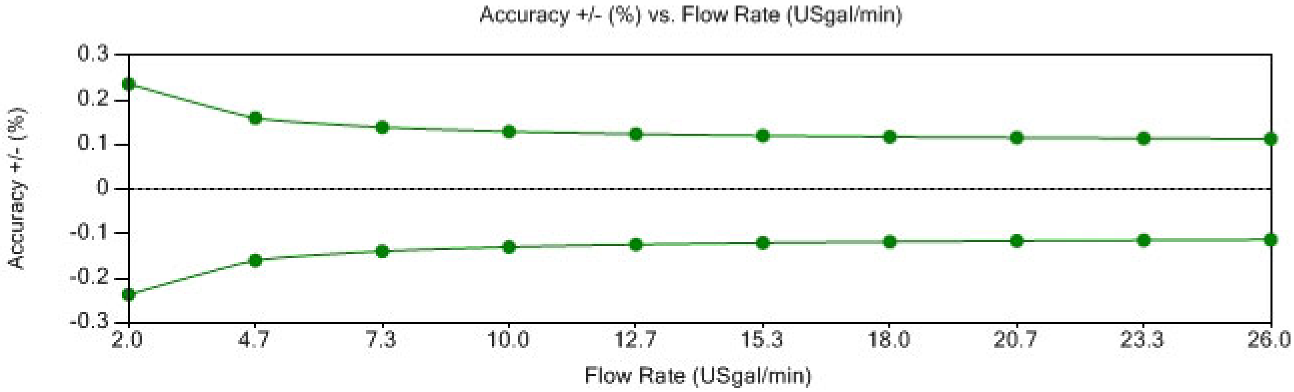
Extended Process Data

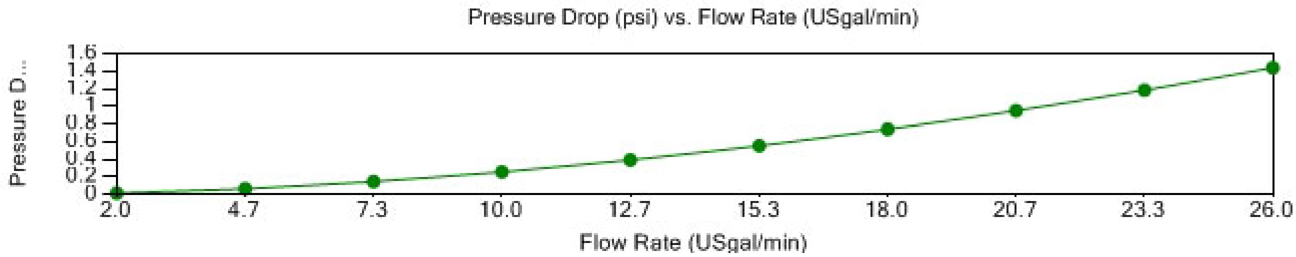
Meter End Connection Type:	Standard
Line Size:	2.00 inches
Mating Pipe Material:	Stainless Steel
	Electrical
Flowtube Electrical Safety Certification:	FM Class I, Division 2
Communications Protocol:	Local through keypad/display
Number of Outputs:	3

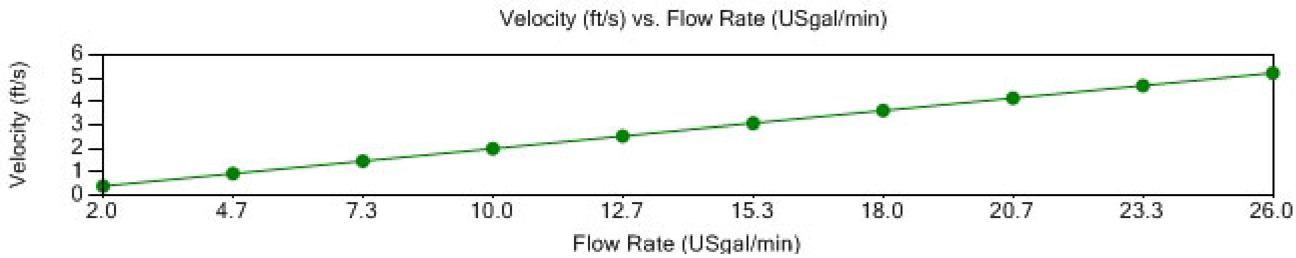
4 - 20 mA:	2
Pulse:	1
Output:	Analog
20 mA (URV):	0.00
4 mA (LRV):	0.00

Sizing	
Meter Size:	CFS10: 1.5000 inches
Maximum Meter Capacity (URL):	54.0 USgal/min
Minimum Meter Capacity:	0.5 USgal/min
Extended Capacity:	80.1 USgal/min
Flow Range:	48.2:1
Pressure Drop at Maximum Process Flow Rate:	1.44 psi
Pressure Drop at Minimum Process Flow Rate:	0.01 psi
Accuracy at Maximum Process Flow Rate:	0.11 %
Accuracy at Minimum Process Flow Rate:	0.24 %
Velocity at Maximum Process Flow Rate:	5.2 ft/s
Velocity at Minimum Process Flow Rate:	0.4 ft/s
Reynolds Number at Minimum Startup Flow Rate:	4434.5
Wetted Material:	316 SS
Flange:	ANSI Class 150
Model Code:	CFS10-15SCFNN

Graphing







Graph Data Points

Flow Rate (USgal/min)	Accuracy +/- (%)	Pressure Drop (psi)	Velocity (ft/s)
2.000	0.236	0.014	0.402
4.667	0.160	0.065	0.939
7.333	0.139	0.147	1.475
10.000	0.129	0.257	2.012
12.667	0.124	0.394	2.548
15.333	0.120	0.555	3.085
18.000	0.118	0.742	3.621
20.667	0.116	0.951	4.158
23.333	0.114	1.184	4.694
26.000	0.113	1.440	5.230

Please consult factory for additional information.
Inside U.S.: 1-866-PHON-IPS (1-866-746-6477)
Outside U.S.: 1-508-549-2424
FlowExpertPro.com Revision 1.303

As can be seen with an examination of the results of this report, the nominal input parameters were estimated as follows:

- Flow Rate; 24 gpm
- Temp; 60 deg F
- Pressure; 50.0 psig
- Density; 2 SG
- Viscosity; 2.0 centipoise
- Line Size; 2.0 inches.

The sizing results include the meter size, maximum meter capacity, minimum meter capacity, extended capacity, flow range, pressure drop at maximum and minimum flow rates, accuracies at maximum and minimum process flow rates, velocity at maximum and minimum process flow rates, Reynolds number at minimum startup flow rate, wetted material, flange class and size, and model code.

The sizing program is intuitive and easy to use. If technical help is required, it is accessible via telephone or on the web site.

It is recommended that a Coriolis flow sensor be utilized in connection with the volumetric stroke counter discussed previously. In fact, it is recommended that two mass-flow sensors be utilized—one mounted in a small circulating loop at the grout low-pressure subsystem and one on the output of the low-pressure pump at the grout low-pressure subsystem. The purpose in utilizing two sensors would, theoretically, be a technique to determine the percent of air content contained within the grout in the form of air bubbles. It is estimated that the flow rate for the small circulating loop at the grout low-pressure subsystem would satisfactorily be in the range of from 1 to 5 gpm.

Until recently, the capability for any single instrument to accurately measure the volumetric or mass-flow of a fluid with an entrained gas has not been available. With the development of Coriolis meters it has become possible to measure the density and mass-flow of fluids very accurately and with the addition of digital processing circuitry, it is now possible to accurately measure the mass-flow of two-phase fluids. In fact, this technology has resulted in accuracies of two-phase flow sufficient that it is postulated that the use of two Coriolis flow meters mounted in a system to monitor the density of the same homogenous fluid at divergent pressures will be able to predict the GVF (gas flow fraction) by comparing the densities as measured by the two sensors.

The Foxboro Company, a division of Invensys, has been a leader in this advanced technology. The following link will connect to a file that provides interesting information relative to this development: http://www.automationtechies.com/sitepages/pid1353.php.

In a recent email exchange, I quote a statement from Mr. Chris Lesser (Tel: 303-321-5144) of Foxboro:

"For smaller GVF (say less than 2%) our accuracy is +/- 0.015 g/cc. Based on simple component balance it looks like a 1 wt% change in air content correlates to ~20 g/cc difference in overall density. 0.1% change correlates to ~2 g/cc, well within meter accuracy. At larger Gas Void Fractions accuracy will be less (but still within meter capability). Measurement may also be more noisy because fluids are typically less consistent or homogeneous at larger GVFs."

Foxboro has indicated the possibility of providing some Coriolis instrumentation if Bechtel BBWI or a prospective subcontractor is interested in running some tests with the intention of purchasing some meters if the tests are successful.

The reason for the concern over the presence of air entrapped in the grout is because it becomes a serious safety issue when the pressure of the grout is escalated up to 8500 PSIG.

Appendix I

Monitoring the Status of the Drill Bit Orifices

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Appendix I

Monitoring the Status of the Drill Bit Orifices

The size of the drill bit orifices, flow characteristics (such as viscosity) of the grout, output pressure at the discharge of the high-pressure pump, affect of any other variables in the high-pressure piping (such as the development of significant leaks or obstructions) all contribute to the mass flow rate of the grout. Assuming that all parameters hold steady with the exception of the erosion of the orifices, the mass flow rate will be a good indicator of orifice erosion due to grout abrasion. Consequently, monitoring and trending the mass flow rate will contribute to minimizing unscheduled downtime, uniformity of the grout columns, and efficiency of the grout injection task.

As pointed out above, orifice erosion is not the only contributor to variation in mass flow rate of the grout. In order to be able to accurately predict the root cause of mass flow variation, it will be important to monitor and trend the measurable parameters of both density and high-pressure pump output pressure.

The following is an excerpt of emails from Ernie Carter of Carter Technologies Company:

"We should be more careful to distinguish between volumetric flow rate and slurry density. Mass flow rate is not a parameter we need to measure directly. The density of the grout slurry will vary significantly with time and is a key quality control parameter. The volumetric flow rate is also critical. As the jets wear and enlarge, we must receive this data and increase the rotational speed and lift rate of the jet bit to compensate so that each hole receives the same amount of grout. The pump operator will also have to increase the throttle setting to maintain uniform pressure as this wear occurs. Changes in slurry density have a significant effect on flow rate at a given pressure and jet orifice diameter. The pump operator will adjust gears and throttle to maintain uniform pressure, but must be able to increase pressure if directed to by the drill operator. The drill operator will increase pressure when encountering very hard formations, where grout returns become more fluid than normal, indicating the jets are unable to fully penetrate the soil."

"We will be using two jets of equal size. When one or both jets plug the pressure will spike and the pump will automatically shut down. The drill operator will then activate the bit replacement system to remotely remove and install the new bit."

"The wear due to the abrasive grout will be directly related to total flow at a given rate and grout design. It is not the flow of the grout, or the mass of sand pumped that causes the wear so much as the grout dragging abrasive sand along the steel surface. Just as oil in your car keeps metal from touching metal, the grout must keep the sand grains from touching the steel."

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Appendix J

Monitoring Grout Pressure

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Appendix J

Monitoring Grout Pressure

It is expected that the cementacious grout will be abrasive to the piping, hoses, fittings, valves, sensors, and pumps. The low-pressure and high-pressure pumps will experience wear and tear from the abrasiveness of the grout, and a good indicator of the condition of the pumps will be a continuous readout of the pump output pressure. The nominal pressure at the output of the high-pressure pump will be 8500 psig. Pressures in this range are dangerous and the design will require material, devices, and fittings to safely withstand and transmit the high pressure—as sensed at the high-pressure piping—to the pressure transmitter.

Below are various links to information on high-pressure transmitters and their manufacturers:

- Manufacturer's Index for High Pressure Transducers/Transmitters
- Ashcroft Model V2 Performance Specifications
- Ashcroft cut sheet and Ordering information
- Pressure Transmitter/Transducer Accuracy definition
- BSI Controls (pdf)
- http://213.210.30.89/delta/documents/387.pdf.

In order for the high-pressure sensing system to function reliably, careful consideration must be given to the selection of a diaphragm seal with an armored capillary tube to interface the high-pressure transmitter to the high pressure of the flowing grout in the piping. The following link provides a selection table sheet for a Ashcroft series 400 diaphragm seal: http:/www.ashcroft.com/library/type_400_500.pdf. Ashcroft technical assistance is available at 203-385-0217 or their web site at www.ashcroft.com.

The 316 stainless steel, armored capillary assembly can be specified for any desired length in 5 foot increments and is flexible and safe to use. Ashcroft manufactures the series 400 diaphragm seal with an XHP option that brings the pressure rating for the diaphragm seal and armored capillary assembly to 15,000 psig. The hyperlink references above include the Delta series 387 Hi-Pressure Transmitter. The combination of the Delta Hi-Pressure Transmitter and the Ashcroft series 400 diaphragm seal with armored capillary assembly is the recommended path to follow for the design of the high-pressure grout measurement components. It is also recommended that the available option for a “flushing” connection on the diaphragm seal be specified. The flushing connection will simplify the periodic requirement to flush and rinse out the process side of the diaphragm to clean it from grout buildup.

It is also recommended that a diaphragm seal with a flushing connection be specified for the pressure measurement at the output of the low-pressure pump.

The pressure transmitters selected should have local readouts in scalable engineering units or independent pressure gauges for the benefit of the trackhoe operator and the equipment tender(s) for the grout low-pressure and high-pressure subsystems.

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Appendix K

Monitoring Vibration of the Low-Pressure and High-Pressure Pumps

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Appendix K

Monitoring Vibration of the Low-Pressure and High-Pressure Pumps

Every rotating machine has its own vibration signature that can change when the machine experiences internal changes such as bearing wear or imbalances. The key point for predictive maintenance is to locate the defect through vibration analysis before the machine catastrophically fails. State-of-the-art technology includes vibration monitors that have an integrated accelerometer, signal processor, and diagnostic electronics in a compact package. These units are designed to be permanently mounted on a pump to monitor failure conditions of internal parts, bearings, or shafts. An example of this type of monitor can be found at: http://www.ifmefector.com/ifmus/web/octavis_home.htm.

This device, manufactured by IFM Efector, Inc., requires 24-VDC power and has configurable relay contacts that will change state when the unit trips. It also has the feature of communicating via a laptop computer with downloaded Parameter Configuration software. This software provides the means of configuring the unit and analyzing the monitored pump online to prevent unpredicted failure.

Installation of a vibration monitor on the low-pressure grout pump may not be necessary because cavitation is normally what causes low-pressure grout pumps to fail, and cavitation makes distinctive sounds to alert the operator that cavitation is occurring. However, it should be considered as a parameter worth trending over time. Pumps are rotational devices subject to bearing wear, and without a vibration monitor the early warnings of bearing failure will probably not be detectable.

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Appendix L

Monitoring Verticality of the Drill Rig

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Appendix L

Monitoring Verticality of the Drill Rig

As the drill rig is positioned to drill a hole, it will be important to drill the hole as vertically as possible. This can be accomplished if the verticality of the drill rig at every instant of time is fed back to the trackhoe operator. This type of data may or may not be available as a standard or optional feature provided by the trackhoe or drill rig manufacturer. (This would be the preferable situation.) If it is necessary to add this capability via custom engineering, there is instrumentation available to accomplish it. One method would be to mount two absolute inclinometers on two orthogonal structural members of the drill rig. For example, US Digital Corporation manufactures an absolute inclinometer with a field programmable resolution that would be accurate to 0.1 degree. This unit is provided with several output options. Data for this particular unit is available at: http://www.usdigital.com/products/a2t/index.shtml.

If it is determined that the signal from the inclinometer need go no further than the trackhoe cab, the following links describe the recommended digital display and cable options to interface with the A2T inclinometer:

- http://www.usdigital.com/products/ed2/
- http://www.usdigital.com/products/connect/.

The manufacturer's data for this unit points out that although the unit is sealed and should withstand wet applications reasonably well, it is not waterproof. Since this application will require waterproof equipment, mounting the inclinometer in a NEMA 4-x box with a waterproof cable connector plug can solve this problem.

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Appendix M

Monitoring Level of Grout in the Supply Tank

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Appendix M

Monitoring Level of Grout in the Supply Tank

It will be required to continuously monitor the level of grout in various tanks or hoppers. Specifically, the following hoppers will require level sensor-transmitters:

- Grout receiving-agitator hopper receiving grout slurry from the grout mix plant
- Grout receiving hopper that feeds the low-pressure pump at the grout low-pressure subsystem.

The purpose of monitoring the level in the grout receiving hopper at the grout low-pressure subsystem will be to provide a real-time status of the grout level so that operations can adjust to assure that the grout level does not drop to the point where air would gain entry into the low-pressure inlet of the low-pressure pump. This introduction of air will cavitate the pump and propagate air into the high-pressure pump. The presence of air in the grout will be a source of trouble to both pumps and also create a safety hazard as the air is compressed by the high-pressure pump.

The recommended level sensor-transmitter to use in the liquid grout applications is an ultrasonic transducer-transmitter combination device. An ultrasonic sensor works by bouncing an RF signal off the surface of the fluid and calculating the time it takes for the signal to return to the transducer. With this device, direct contact with the grout is avoided and will eliminate the problems that occur with product buildup on the sensor. The following links will connect to an ultrasonic transducer-transmitter manufactured by Siemens called “The Probe” or SITRANS PROBE, Model LU:

For introductory information; https://pia.khe.siemens.com/index.asp?Nr=11159

For additional information concerning the SITRANS Probe LU; https://pia.khe.siemens.com/index.asp?Nr=11157

For Siemens service and support; http:/www4.ad.siemens.de/-snm-0135030360-1084460314-0000000609-0000000292-1087504768-enm-WW/llIsapi.dll/func=cslib.csinfo&lang=en&siteid=cseus&aktprim=08startNode=4000024&nodeIDO=19100600&basisview=4000003&viewlevel=6&wttree=cs&foldersopen0=-1932.

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Appendix N

Wireless Transmission of Data

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Appendix N

Wireless Transmission of Data

Conceptually, a plan for collecting, monitoring, and organizing field measurements will involve wireless transmission of field data to a SCADA system located at the RMF in a mobile trailer. There are a large number of manufacturers who have developed wireless systems, but the focus in this report is to identify a system and include enough information to conceptually define the functional hardware that would be required for a workable system.

In order to keep the system as simple as possible, it is recommended that a single manufacturer be selected whose COTS equipment spans the integration of field I/O (inputs and outputs–digital and analog), communication interface modules, and wireless transmitters and receivers.

For this report, the equipment manufactured by Moore Industries-International, Inc.(818-894-7111, Moore Industries) has been selected to serve as an example of a workable system. (see Figure 7 of Appendix D for a block diagram of the equipment described here).

Moore Industries-International, Inc. manufactures a wireless link module for either Ethernet or serial interfaces. This is referred to in their literature as: "WLM Wireless Link Module")WLM). When these devices are integrated with a Moore Industries-International, Inc. "NET Concentrator System," distributed I/O (Net Concentrator), WLM can be operated in point-to-point or point-to-multipoint architectures.

The SCADA system, including computer hardware and operating system, must communicate with the net concentrator system via the WLM wireless Ethernet link. The system proposed and described here will consist of the computer hardware described in the following illustration, including Windows XP Professional O/S.

The recommended HMI software is Rockwell's RsView32 configured with the MODBUS ICP driver. This will communicate directly with the Moore Industries-International, Inc. net concentrator distributed I/O system.

For specific information about RsView32, see: http://www.software.rockwell.com/rsview32/

For information about extending the HMI to authorized people via the web, see: http://www.software.rockwell.com/rsview32webserver/

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